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LECTURES

ON

SURGICAL PATHOLOGY AND THERAPEUTICS.

A HANDBOOK FOR STUDENTS AND PRACTITIONERS.

BY

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GENERAL SURGICAL PATHOLOGY AND THERAPEUTICS.

LECTURE I.

INTRODUCTION.

The relation of surgery to internal medicine.—Necessity of a practitioner's having acquired both.—Historical remarks.—The method of study of surgery pursued in the German universities.

GENTLEMEN.—The study of surgery, which you commence with these lectures, is in most countries at present rightly regarded as a necessity for the medical practitioner. We consider it a sign of progress that there is no longer the same separation of surgery from medicine as was formerly the case. There is in fact only an apparent distinction between internal medicine and surgery, the separation is artificial, although founded on history and on the great and ever increasing extent of medicine generally. You will often notice in the course of these lectures how very much surgery has to take into consideration the internal and general processes in the body, also that external and internal affections are in all respects analogous, and that the whole difference is in the fact that in Surgery the local alterations of tissue are mostly patent, whilst we only judge of the local affections of internal organs from the functional disturbances. The effects of local disturbances on the condition of the system in general, must be as accurately understood by the surgeon as by one whose attention is principally occupied with diseases of the internal organs. In short the surgeon must be a physician also in order to form a correct and safe judgment as to the condition of his patient. On the other hand the physician who puts surgical cases

on one side and only attends to the treatment of internal complaints, must have some surgical knowledge if he would avoid making the most unjustifiable mistakes. Independently of the fact that the country doctor does not always have a colleague within reach to whom he can hand over his surgical cases, the life of a patient may at times depend on a rapid and correct diagnosis of some surgical disease. When blood is spouting from a wound, when a foreign body has entered the wind-pipe and the patient is threatened with immediate suffocation, then is the time for surgical interference, and that quickly, or the patient is lost. It may happen in other cases that a physician without any knowledge of surgery may do much harm by his incapacity of forming a judgment as to the importance of a disease; he may allow the complaint which at first might have been easily relieved by surgical aid, to become incurable and thus by his want of knowledge cause unspeakable injury to the patient. It would for this reason be most unjustifiable should a physician perversely persist in the idea of only practising internal medicine, still more unjustifiable would it be for you even to think of neglecting the study of surgery: to say, "I will not operate, as there are so few operations in general practice, and personally I am not fitted for it!" As if surgery consisted in operating only! as if surgeons only needed skilful hands in order to do their work properly: I hope to present you with a better view of this branch of medicine than that represented, which is unfortunately only too popular.

As surgery has to deal chiefly with palpable injuries, it certainly has a somewhat easier position with regard to the anatomical diagnosis, but do not estimate this advantage too highly! Quite apart from the fact that affections requiring surgical treatment are often deep-seated and hidden from view, much more is expected from a surgical diagnosis and prognosis and even from the treatment than is expected from the therapeutic action of internal remedies. I do not deny that internal medicine may in many respects possess greater attractions just because of the difficulties which it has to surmount in the localisation and recognition of disease, difficulties often so successfuly vanquished. Very fine mental operation is frequently neccessary in order to obtain a clear idea from the complexity of the symptoms and the results of the examination. Physicians may point with pride to the anatomical diagnosis of diseases of the heart and chest, since by their indefatigable spirit

of inquiry they have been enabled to give as accurate a representation of the changes in the affected organ as if they were present to the eye. How marvellous it is to be able to get a clear idea of the diseased condition of deep-seated organs, as the kidney, liver, spleen, the intestines, the brain and spinal cord, by means of an examination of the patient and the combination of the symptoms. What a triumph to be able to diagnose diseases of organs, of whose physiological functions—the supra-renal capsules for instance—we have not the slightest idea. This somewhat indemnifies us for the fact that in internal medicine we have more frequently than in surgery to confess our powerlessness respecting the operation of our mode of treatment, although the treatment of internal complaints has, owing to the progress of anatomical diagnosis, become more certain and more definite as to its object and the results attainable.

The attraction of the finer reflective qualities of our imagination and intellect to the sphere of internal medicine is, however, abundantly compensated by the greater certainty and clearness of diagnosis and treatment in surgery, so that both branches of medical knowledge not only appear perfectly equal, but what is done in the one is as glorious as that in the other. And we must not forget that the anatomical diagnosis—I mean the knowledge of the pathological changes of the diseased organs—is but a means to an end, that is the cure of the disease. *To find the causes of the morbid processes, to fortell their course correctly, to conduct them to a favourable issue or to check them, these are the peculiar problems for the physician, and these are equally difficult of solution in internal as well as in external medicine; scientific research and refined empiricism are the means at our command for the solution of this problem.*

One thing alone is required of the pure surgeon more than of the pure physician: the art of operating. This, like every other art, requires mechanical skill; operative skill depends upon accurate anatomical knowledge, on practice and on natural talent.

This talent for operating may by constant practice, be successfully cultivated, if there be medical aptitude as well. Remember how Demosthenes overcame the difficulty of speaking!—Owing to this practical part of it, though essentially necessary, surgery, in its narrower sense was so long separated from medicine; historically we can trace how this separation arose, how more and more it

continued to make itself practically felt and only in the course of the present century was it looked upon as unsuitable and was put on one side. In the word "Chirurgery" we find expressed that originally the practical part of the art only was meant, for the word "Chirurgery" is derived from χείρ and εργον; the literal translation being "hand-work," or as it was called in the favourite pleonasm of the middle ages "the craft of Chirurgery."

Little as it is the design of these lectures to give you a complete sketch of the history of Surgery, it still seems to me of importance and at the same time interesting to give a hasty glance at the development of our science and of the position we held, from which you will understand many of the various existing regulations affecting the so-called medical staff in different countries. A more copious history of surgery can only be useful to you later, when you have already obtained some insight into the value or otherwise of certain systems, methods and operations. You will then find the key in the historical development of our science, particularly in respect to operative surgery, for much that is at present surprising and for much concealed knowledge. Much that is absolutely necessary for its comprehension, I will explain to you in speaking of the various diseases; at present I will only bring forward some of the prominent events in the development of surgery and of the surgical status.

Among the nations of antiquity, the healing art was essentially connected with religious culture. It was looked upon among the Indians, Arabians and Egyptians, as well as among the Greeks as a revelation from the Deity to the priests, which spread by tradition. Philologists have not all been agreed as to the age of the recently discovered Sanscrit writings; at first they were believed to have originated about 1000 to 1400 years B.C., at present they believe for certain that they were written in the first century of the Christain Era. The Ayur Veda ("Book of the art of life") is, as regards medicine, the most important work in Sanscrit, and was composed by Súsrutas; this work most probably first appeared in the time of the Roman emperor Augustus. The art of healing was considered in its entirety, as is evident from these words: "Only the association of medicine with surgery forms the perfect physician. The physician who is deficient in the knowledge of one of these branches, resembles a bird with but one wing." Surgery at that time was beyond doubt by far the most advanced department of

the healing art. Much is spoken of a vast number of operations and instruments, but it says very truly that "of all instruments the hand is the best;" the treatment of wounds is simple and appropriate; and most surgical diseases were already known.

Among the Greeks the aggregate of all medical knowledge was concentrated in Asklepios (Æsculapius), a son of Apollo, and a pupil of the centaur Chiron. Many temples were built to Æsculapius, and among the priests of these temples the healing art was transmitted by tradition; in the different temples arose different schools of Æsculapius, and although every one who entered the service of the temple as a priest of Æsculapius, had to take an oath which has been preserved to our own time (though its genuineness has in more modern times become very questionable), that he would only teach the art of healing to the successors of the priests, it yet appears from various circumstances that besides the priests there were other physicians. From what occurs in one part of the oath, it even seems that then, as at present, there were physicians who occupied themselves solely as specialists with certain operations, for it says: "Never will I cut for stone, but will leave it to those men whose business it is." We first obtain more accurate information as to the different kinds of physicians in the time of Hippocrates; he was one of the Æsculapians, was born on the island of Cos about 460 B.C., lived partly in Athens, partly in Thessalonian cities, and died at Larissa 377 B.C. We might well expect that medicine would be scientifically treated at a time when the names of Pythagoras, Plato, and Aristotle, shone in Greek science; and, in fact, the works of Hippocrates, many of which have been preserved to our time, excite our deepest admiration. The clear descriptions, the perspicuous arrangement of the whole material, the enthusiasm for the healing-art as a science, and the keen critical observation which we find in the works of Hippocrates transport us, even in this department, with admiration and reverence for ancient Greece, and show plainly that it was not merely a credulous repetition of traditional medical dogmas, but that there was already a scientifically and artistically formed art of healing.

In the Hippocratic school the art of healing formed a complete whole; medicine and surgery were united; but the medical practitioners were divided into various classes. Besides the Æsculapians there were others, educated physicians as well as the apprenticed medical assistants, gymnasts, quacks, and miracle-mongers; the

physicians took pupils to instruct in their art; and from some observations of Xenophon, we learn that there were already army-surgeons, especially in the Persian wars; they had, together with the soothsayers and flute-players, their position in the neighbourhood of the royal tent. It is natural that special attention would be paid to external injuries at a time when so much was thought of corporeal beauty as among the Greeks; consequently, the study of fractures and dislocations was particularly cultivated among Hippocratic physicians; while, at the same time, we have accounts of many difficult operations, and of a great number of instruments and other apparatus. As regards amputations they certainly seem to have been very backward; probably most of the Greeks would sooner have died than have prolonged life in a mutilated condition; only when the limb was already dead, "gangrenous," was it removed.

At that time the doctrines of Hippocrates could not become further developed, as increased knowledge of anatomy and physiology was necessary; there certainly was a weak attempt in this direction in the learned school of Alexandria, which flourished for some centuries under the Ptolemies, and through which, after the victories of Alexander the Great, the Grecian spirit spread, even though but for a time, into a part at least of the East; the Alexandrian physicians in the meantime soon lost themselves in philosophical systems, and only slightly promoted the progress of the healing art by original anatomical observations. In this school the art was first divided into three separate parts, dietetics, internal medicine, and surgery. With Grecian refinement the Grecian healing art came also to Rome; the first Roman physicians were Greek slaves; the freedmen were permitted to erect baths, and to practise their art in the public baths; here for the first time barbers and bathers appear as our rivals and colleagues, and this association was long injurious to the medical status in Rome. It was only gradually that the philosophically educated possessed themselves of the writings of Hippocrates and the Alexandrians, and then practised the healing art themselves, without however adding anything of importance to it. The great want of original scientific production is shown in the encyclopædical reproduction of the most varied scientific works. The most celebrated work of this kind is the "De Artibus" of Aulus Cornelius Celsus (from 25—30 B.C. to A.D. 45—50 in the reigns of the emperors Tiberius and Claudius); eight books of this, "De Medicinâ," have come down to our time, from which we have

learnt to know the condition of medicine and surgery at that time. Valuable, however, as are these relics of ancient Rome, they only, as already mentioned, place a compendium before us such as is often written at the present day; it has even been contended that Celsus never practised as a physician; this, however, is very improbable; at any rate, we must allow Celsus to be judged from the character of his writings, and the seventh and eighth books, which treat of surgery, could hardly have been so clearly written by any one who understood nothing of his subject practically. From them we see that surgery, especially the operative part of it, had made no inconsiderable progress since the time of Hippocrates and the Alexandrians. Even at this time Celsus speaks of plastic operations and of the herniæ, and describes a method of amputating, which is still occasionally practised. One paragraph in the seventh book, in which he describes the qualifications of a perfect surgeon, has become very celebrated, and as it is characteristic of the thoroughly sound spirit which reigns throughout the book, I will give it to you: "*Esse autum chirurgus debet adolescens, aut certe adolescentiæ propior, manu strenua, stabili, nec unquam intremiscente, eaque non minus dextra ac sinistra promptus, acie oculorum acri claraque, animo intrepidus, immisericors, sic, ut sanari velit eum, quem accipit, non ut clamore ejus motus vel magis, quam res desiderat, properet, vel minus, quam necesse est; secet: perinde faciat omnia, ac si nullus ex vagitibus alterias adfectus oriretur.*"

The surgical instruments found in Pompeii, which was destroyed a few decades after Celsus, demonstrate that the mechanical improvement in these operating implements was already at that time considerably developed; the forceps, nippers, knives, scissors, specula, catheters, &c., which have been preserved in the museum at Naples, are very neatly made of bronze, and are very suitable for their several purposes. It made a peculiar impression upon me, when I saw before me this two thousand year old surgical armamentarium of a Roman colleague, differing but slightly in the form of the more ordinary instruments from those of our time. *Ars longa, vita brevis!*

As one of the most brilliant among the Roman physicians we must reckon Claudius Galenus (A.D. 131—201); eighty-three undoubtedly genuine writings of his have come down to us. Galen again returned to the principles of Hippocrates, inasmuch as he proclaimed observation to be the basis of the healing art; he also

promoted the advance of anatomy very considerably: he mostly used the bodies of apes for dissection and examination, more rarely human bodies. Galen's anatomy, and the whole philosophical system to which he reduced medicine, and which at length stood higher with him than observation itself, were accepted as alone correct for over a thousand years. His importance in the history of medicine is immense. Surgery in particular he advanced but little, indeed he practised it but little, as in his time there were special surgeons, partly gymnasts, partly bathers and barbers, among whom surgery was principally handed down by tradition according to the rules of their craft, while internal medicine was then and continued for a long time in the hands of the philosophically educated physicians who were acquainted with and indeed commented on the surgical writings of Hippocrates, of the Alexandrians, and of Celsus, though they occupied themselves but little with surgical practice.

As this is only a superficial sketch, we may now pass over several hundred or even a thousand years, during which time surgery hardly made any progress and to a certain extent even retrograded. The Byzantine period of the empire was especially unfavourable to the development of the sciences, there was merely a brief revival of the Alexandrian school. Even the most celebrated physicians of the later Roman period, as Antyllus (in the third century), Oribasius (A.D. 326—403), Alexander of Tralles (A.D. 525—605), Paulus of Ægina (660) accomplished comparatively little for surgery. Much had been done for improving the position and scholastic education of physicians: there was a Gymnasium under Nero, an Athenæum under Hadrian, scientific institutions in which medicine also was taught, and a special *Schola Medicorum* under Trajan.

Military medical service was maintained among the Romans, there were also special court-physicians "archiatri palatini" with the title "Perfectissimus," "Eques" or Comes Archiatrorum," as in our time the Germans have Hofräthe, Geheimräthe, Leibärzte, Ordensritter, &c. We have to thank the Arabians that medicine did not quite degenerate with the decline of science in the Byzantine empire. The immense elevation attained by this nation under Mahomed after the year 608, contributed to the preservation of science. Through the Alexandrian school and its branches in the Orient, the schools of the Nestorians, th

with its later improvements reached the Arabians. They cultivated it and brought it, though in a somewhat altered form across Spain into Europe again, until their power was finally destroyed by Charles Martel.

Among the most celebrated Arabian physicians whose writings have been preserved to us, as well as being of the most consequence for surgery, are Rhazes (850—932), Avicenna (980—1037), Abulcasem (× 1106), and Avenzoar (× 1162); the writings of the two latter are of most importance for surgery. Operative surgery suffered considerably from the aversion of the Arabians to shedding blood, which was partly founded on the precepts of the Koran. Instead of the knife the actual cautery was employed to an extent which to us seems hardly credible. The distinctions between surgical diseases became more defined and the certainty of diagnosis improved considerably. Scientific institutions were already much cultivated by the Arabians; the most celebrated being the School of Cordova; in many places there were also public hospitals. The education of physicians was no longer chiefly a private affair, but most medical pupils had to complete their education at scientific institutions. This also exercised an influence on the western nations; next to Spain, Italy was the chief place where the sciences were cultivated. In South-Italy arose a very celebrated medical school, that of Salerno, in the lovely city so beautifully situated to the south of Naples in the Gulf of Salerno; it was probably founded by Charles the Great in 802, and stood at the height of its glory somewhere about the twelfth century; according to the most recent researches this was no monastic school, but all the teachers were laymen; there were also lady-teachers who took an active part in literature; the best known of these is Trotula. There was little or no original research, but the writings of the ancients were followed.

This school is also interesting from the fact that it is the first corporation we find having the right to grant the titles of "Doctor" and "Magister."—Emperors and Kings began to take more and more interest in science and founded universities. In Naples in 1224, in Paris 1205, in Salamanca 1243, in Pavia and Padua 1250, and in Prague in 1348, universities were established and the right of conferring academical degrees granted to them. Philosophy was the science most in vogue and medicine retained for a long time her philosophical garb at the universities; at one time Galen's system was followed, at another the Arabian, at another the modern

medico-philosophical, and all observations were recorded according to these systems. This was the chief obstacle to the progress of the natural sciences, a species of mental shackle, from which even the most noted men could not wholly divest themselves.

The anatomy composed by Mondino de Luzzi in 1314 is but little different from that of Galen, in spite of the author's relying upon the dissection of human bodies.

As regards surgery no real advance had been made. Lanfranchi (× 1300), Guido of Cauliaco (in the beginning of the fourteenth century), Branca (about the middle of the fifteenth century) are a few noteworthy names of celebrated surgeons of that time.

Before turning our attention to the flourishing condition of the natural sciences and of medicine in the sixteenth century, we must take a brief survey of the mode of classification of medical men in their respective positions in the times of which we speak, as this is important for its history.

In the first place there were philosophically educated physicians, partly laymen and partly monks, who taught medicine at the universities and other learned schools, that is, they commented on the writings of antiquity on anatomy and surgery as well as on special medicine; these men certainly practised but had little to do with surgery.—A further seat of the sciences was in the cloisters; the Benedictines particularly paid a great deal of attention to medicine and also practised surgery, although the superiors disliked seeing it, and occasionally a special dispensation for an operation had to be applied for. The regular practising physicians were partly resident and partly travelling. The former as a rule had been educated at scientific schools and only obtained the right to practise on certain conditions.

The emperor Frederick II, in 1224, introduced a law by which these physicians were obliged to study logic (*i. e.*, philosophy and philology) for three years, medicine and surgery for five years, and finally had to practise for some time under the supervision of an older physician, before obtaining the right to practice on their own account; or as an examiner lately remarked of the physicians who had just graduated, "before being let loose on the public." Besides these resident physicians, of whom a great part were either doctor or magister, there was a large number of "travelling physicians," a kind of "travelling student," who exercised their calling for money, travelling from one market to another in a cart in

company with a clown or merry-andrew. This species of so-called charlatans, who played an important rôle in the dramatic poetry of the middle ages, and even at the present day is greeted on the stage with uproarious applause by the public, led a wretched existence at that time; they were looked upon as dishonorable, like the pipers, jugglers, and public executioners. Even now these charlatans are not quite extinct, although in the 19th century it is not at the fairs that they follow their occupation, but in the drawing-rooms as miracle-mongers, especially as cancer-doctors, herbalists, somnambulists, &c.

If we inquire as to the relation between this mixed company and those who practised surgery, we shall find that this branch of medicine was occasionally practised by almost all of them; there were, however, physicians practising surgery in particular, who associated themselves into guilds, and formed honorable civic corporations. These first received their practical knowledge from a master to whom they were apprenticed, and later partly from books and partly at scientific institutions. These persons had the principal share of operative surgical practice in their hands; they were mostly resident, but some of them travelled about as herniotomists, lithotomists, and oculists. Later we shall become acquainted with some first-rate men among these old masters of our art. Besides these, the bathers, and at a later period the barbers, as with the Romans, practised surgery and were legally empowered to practise "minor surgery;" *i.e.*, they might cup or bleed, and treat fractures and dislocations. Among the different grades of physicians disputes naturally arose as to their various privileges, which were hardly ever accurately defined; this was particularly so in the large cities, where all descriptions of doctors were established. It was especially the case in Paris. The surgical guild there, the "College of St. Côme," wanted equal rights with the associates of the medical faculty, more especially they aspired to the baccalaureate and licentiate. The "Corporation of Barbers and Bathers" again wanted to practise surgery in all its branches, just as the fellows of the College of St. Côme. In order to annoy these latter, that is the surgeons, the associates of the faculty supported the wishes of the Barbers, and in spite of occasional mutual compromises the disputes continued, one may even say, that they still continue, wherever there are *chirurgi puri* (surgeons of the first class and barbers) and *medici puri*. It is only about ten years since this class distinction has been abolished

in all German states by granting degrees neither to *chirurgi puri* nor to *medici puri*, but to physicians who practise medicine, surgery and midwifery simultaneously. In conclusion, as to the external rank of physicians, we would remark that in England alone there still exists a tolerably defined line of demarcation between surgeons and physicians, chiefly in the cities, while in the country the "general practitioner" practises surgery and medicine together, and at the same time keeps an apothecary's shop.

In Germany, Switzerland, and in France, it often happens that, owing to circumstances, a physician practises more surgery than medicine; the male portion of the medical staff, however, consists legally only of physicians and their assistants, or barber-surgeons, who, on passing the legal examination, are licensed to cup, bleed, &c. This regulation has been finally adopted in the organization of the army, in which the so-called company-surgeon with the rank of sergeant-major, formerly had a miserable position under the battalion and regimental physicians. Quite recently perfect freedom in medical practice has been established in the German empire; that is, everyone who likes may give medical advice and take payment for it; those who have passed the state-examination alone have the right to the title of "medical practitioner" (praktischer arzt); the sick public is now at liberty to choose whether it will consult the one or the other.

If we now resume the thread of the historical development of surgery, we must, as we now enter upon the period of the "Renaissance" in the sixteenth century, before all things remember the great advance which was then accomplished in nearly all the sciences and arts by means of the reformation, of the invention of printing and of the awakening genius of criticism in educated countries. The observation of nature began again to assert its rightful position and to free itself, though but slowly and gradually, from the fetters of scholasticism. The search after truth again assumed its right to be regarded as the essential nature of science! The Hippocratic spirit was re-awakened. Above all things it was the revival, we may almost say the re-discovery of anatomy and the subsequent continually progressive development of that science, which levelled the ground.

Vésal (1513—1584), Fallopia (1532—1562), and Eustachio (× 1579) became the founders of modern anatomy; their names, like many others, are already known to you from the names of

different parts of the body. The sceptically critical attitude which was assumed towards the prevailing Galenical and Arabian systems was chiefly owing to the celebrated Bombastus Theophrastus Paracelsus (1493—1554), and observation was recognised by him as the chief source of medical knowledge. When, at length, William Harvey (1578—1658), discovered the circulation of the blood and Aseli (1581—1626) the lymphatic vessels, the old anatomy and physiology had to give way completely and to make room for modern science, which thenceforth steadily progressed down to our own time. It was a long time, however, before practical medicine could free itself in a similar manner from the constraint of philosophy. Systems were raised upon systems; and the theories of medicine were again and again varied to suit each prevailing fashion of philosophy. We may say, that it is only since the great advance of pathological anatomy in the present century that practical medicine has obtained a firm anatomico-physiological basis, on which it now almost entirely moves, and which forms a powerful protection against all philosophical medical systems. But with this anatomical direction there are the dangers of exaggeration and one-sidedness. Later we shall have to speak of this occasionally.

We will now give our exclusive attention to the scientific development of surgery from the sixteenth century down to our own time.

It is an interesting feature of that time that the advancement of practical surgery proceeded more especially from the incorporated surgeons, and less from the learned professors of surgery at the universities. German surgeons had mostly to get their knowledge at foreign universities, but some part of it that they worked out was entirely original; Heinrich von Pfolsprundt, a member of a German ecclesiastical order (born at the beginning of the fifteenth century), Hieronymus Brunschwig (born 1430 at Strassburg, of the race of Salern), Hans von Gersdorf (about 1520), and Felix Würtz (× 1576), surgeon at Basel, are the first of any note; we possess writings of all of them; Felix Würtz appears to me to be the most original of them, he had a keen critical mind. Of greater attainments were Fabry von Hilden (1560-1634), a physician at Berne, and Gottfried Purman (1674-1679), surgeon in Halberstadt and Breslau. These men, whose writings show a high scientific inspiration, fully understood the value and the absolute necessity of accurate anatomical knowledge, and promoted it to the

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[illegible] having reference to the chaotic
[illegible] of his treatises on the treatment
[illegible] are thoroughly classical; by the
[illegible] for bleeding vessels in amputations he
[illegible] Paré may be placed as the reformer of
[illegible] Vesal, the reformer of anatomy.
[illegible] men we have named, including those of others
[illegible] held an influential position in the seventeenth
[illegible] in the eighteenth do we find any fresh advances of
[illegible] contest between the members of the faculty and
[illegible] College de St. Côme still continued in Paris, the most
[illegible] individuals of the latter accomplishing far more than the
[illegible] of the faculty of surgery. This was at length practically
[illegible] in the year 1731 by the foundation of an "Academy of
[illegible]" in every respect equal to the medical faculty. This institution soon attained such a height, that for nearly a century the whole surgery of Europe was regulated by it; nor was this an isolated case, but was a part of the general French influence, of that universal intellectual dominion which at that time French science and art had deservedly acquired by the eminent services it had rendered.

The men, who at that time stood at the head of the movement in surgical science, were Jean Louis Petit (1674—1766), Pierre Jos. Desault (1744—1795), Pierre François Percy (1754—1825), and many others in France. In Italy, Scarpa (1748—1832) did more than any one else. Already in the seventeenth century surgery was considerably developed in England, and in the eighteenth century attained great eminence under Percival Pott (1713—1768), William and John Hunter (1728—1793), Benjamin Bell (1749—1806), William Cheselden (1688—1752), Alex. Monro (1696—1767) and others. Among these John Hunter was the greatest

genius, equally celebrated as an anatomist and as a surgeon; his work on inflammation and wounds still forms much of the groundwork of our present views on those subjects. Compared with the lustre of these names, those of German surgeons of the eighteenth century must modestly retire into the background, honest and earnest as were their efforts. Lorenz Heister (1683—1758), Joh. Ulrich Bilguer (1720—1796), Chr. Ant. Theden (1719—1797) are relatively the most important German surgeons of that time. Greater progress in German surgery was first made with the commencement of the present century. Carl Casp. v. Siebold (1736—1807) and August Gottlob Richter (1742—1812) were distinguished men; the former was professor of surgery in Würzburg, the latter in Göttingen; of the writings of Richter some have retained their value to the present day, particularly his little book on ruptures.

Here on the threshold of our century, you again see professors of surgery occupying a foremost place, and henceforward they maintain their position, because they really exercised their profession practically. A predecessor of old Richter in the professorial chair of surgery at Göttingen, the celebrated Albert Haller (1708—1777), at once physiologist and poet, one of the last encyclopædists, says: "*Etsi chirurgiæ cathedra per septemdecem annos mihi concredita fuit, etsi in cadaveribus difficillimas administrationes, chirurgicas frequenter ostendi, non tamen unquam vivum hominem incidere sustinui, nimis ne nocerem veritus.*" We can hardly imagine this, so immense is the revolution that the short space of a hundred years brings with it.

Even at the commencement of our century the French surgeons still remained at the helm. Boyer (1757—1833), Delpech (1777—1832), but particularly Dupuytren (1777—1835) and Jean Dominique Larey (1776—1842), exercised an almost unlimited, but, at the same time, enlightened absolutism in their art. Beside them arose in England the unassailable authority of Sir Astley Cooper (1768—1841). Larey, the constant companion of Napoleon I, left a large number of works; at some future time you will read his memoirs with great interest. Dupuytren did most service by his highly intellectual and sound clinical lectures. Cooper's monographs and lectures will fill you with admiration. Translations of the writings of the French and English surgeons we have mentioned had the immediate effect of stirring up German

surgery; and very shortly there appeared original work of the most thorough character on this subject. The men who gave life to this national resurrection of German surgery were, among others, Vincent von Kern, in Vienna (1760—1829), Joh. Nep. Rust in Berlin (1775—1840), Philipp von Walther (1782—1849) in Munich, Carl Ferd. von Graefe (1787—1840) in Berlin, Conr. Joh. Martin Langenbeck (1776—1850) in Göttingen, Joh. Friedrich Dieffenbach (1795—1847), and Cajetan von Textor in Würzburg (1782—1860).

The nearer we approach the middle of the present century, the more do the rugged boundaries of nationalities disappear from the domains of surgery. With increased means of communication, every scientific advance is spread over the whole civilized world with a speed that could never have been anticipated. Numberless journals, national and international congresses, individual intercourse of the most varied kind, have brought about an active interchange of ideas of surgeons with each other. The schools, which in the older and narrower sense of the word were attached to certain prominent men or groups of such men at some particular locality, are at an end. It appears as if a generation of surgeons, on whose great services we of the present time look with respect, were just dying out. I mean men like Stanley (1791—1862), Lawrence (1783—1867), Brodie (1783—1862), Syme (1799—1870) in Great Britain; Roux (1780—1854), Bonnet (1809—1858), Leroy (1798—1861), Malgaigne (1806—1865), Civiale (†1867), Jobert (1799—1868), Velpeau (1795—1867) in France; Seutin (1793—1862) in Belgium; Valentine Mott (1785—1865) in America; Wutzer (1789—1863), Schuh (1804—1865), Franz von Pitha (1810—1875)) and others, in Germany! And from our own generation also we have to mourn over some bitter losses, beyond all others the irreparable death of the highly-gifted and indefatigable investigator O. Weber (1827—1867), of the eminent Follin, one of the soundest of modern French surgeons (†1867), of Middeldorpf (1824—1868), the celebrated inventor of galvano-caustic operations! Among the living there are still many who might be mentioned, on whose shoulders rests the present generation of German surgeons; but as it is hardly agreeable to any one to become historical during his lifetime, I forbear to quote any more names!

One important event however in the modern history of surgery I

must not leave unmentioned, that is, the introduction of remedies to allay pain. The nineteenth century may well be proud of the discovery of sulphuric ether and chloroform, which may be practically employed as anæsthetics in all kinds of operations. The first communication came from Boston in the year 1846, to the effect that a dentist named Morton had been induced by his friend Dr. Jackson to employ inhalations of sulphuric ether for the production of complete anæsthesia during the extraction of teeth, and with the most brilliant result. In 1849 the still more effectual chloroform was introduced into surgical practice, in place of the ether, by Simpson, late professor of midwifery in the University of Edinburgh (1811—1870), and, notwithstanding many and various experiments with other similar materials, chloroform still holds its ground to the present time, beyond the most sanguine anticipations. Thanks! a thousand thanks to these men, in the name of suffering humanity.

With regard to my former observations respecting German surgery, I will in conclusion only add that it now stands in a position at least equal to that of other nations. It is nevertheless clearly desirable that every physician should enlarge his experience and observation in other countries. From a practical point of view, England, America, and Germany, seem to me to be of greater importance for surgery than any other countries. From the time of Hunter to the present time English surgery has had something of grandeur and style about it. The surgery of the nineteenth century in Germany owes its greatest rise to the circumstance that it has endeavoured to unite all medical knowledge in itself on the basis of a sound anatomical and physiological foundation; the surgeon who succeeds in this, and in addition also masters completely the entire mechanical part of surgery, may boast that he has reached the highest ideal point in the whole of medicine.

Before we enter upon our subject I will premise a few remarks on the study of surgery as at present it is or ought to be carried on in our universities.

If we retain the four years usually allowed for the study of medicine in German universities, I would advise you not to begin surgery before the fifth half year's session. There is very frequently an effort among you to endeavour to get over the preparatory lectures as soon as possible, in order to get quickly to the practical part. This is

certainly somewhat less the case since in most of the high schools courses have been established on anatomy, microscopy, physiology, chemistry, &c., in which you are practically occupied; nevertheless, there is always over-eagerness to enter the clinical wards. It is, in truth, one way of gaining a certain amount of experience from the very commencement, and it appears much more interesting than worrying yourself with things whose connection with practice you cannot as yet rightly comprehend. But you forget that a certain amount of practice in the school of observation has to be gone through before you can extract the really useful from your experiences. If any one just released from the control of school were at once to enter a hospital as a student, he would in this novel situation be like a child entering the world to collect experience for life. Of what good is the experience of the child in respect to its future worldly wisdom, and to teach it the art to live among men? How late it is before we find the true value of the most ordinary observations of our daily life. And in the same way it would be very slow and tedious to work empirically through the whole development of medicine, and only a very gifted, restlessly energetic man could do any good in this way, after having passed through the most varied phases of error. We must not rate "experience" and "observation" too highly, if by them we understand no more than the laity; it is an art, a talent, a science, to observe critically, and to draw from these observations correct conclusions as our experiences; this is the strong point of empiricism. The public only recognises experience in the vulgar, not in the scientific sense, and values the experience and observation of an old shepherd as highly as, sometimes even higher than, that of a physician. But enough; if a physician or any one else parades his experience and observations before you, just notice what kind of intellect is possessed by the narrator. In making this attack upon natural empiricism I do not mean to assert that you must necessarily get a perfect theoretical knowledge of medicine in its entirety before commencing practice, but you must bring with you into the wards of the hospital an intelligent acquaintance with the fundamental principles of the scientific investigation of pathological processes. It is absolutely necessary that you should have a general idea of what you are to expect at the bedside; you must also be acquainted with your implements before seeing them used or handling them yourself. In other words, you must know the outlines of general pathology, the-

rapeutics, and materia medica, before commencing your bedside study of patients. General surgery is but a division of general pathology, and should therefore be studied before attending clinical surgery. At the same time you must, if possible, get a clear insight into normal histology, at least the general part of it, and you should study pathological anatomy and histology, together with general surgery, some time during the fifth session.

General surgery, which we are about to discuss in these lectures, is, as already mentioned, a part of general pathology, but stands in a far nearer relationship to practice than the latter. It is the doctrine of wounds, inflammations, and tumours of the exterior of the body and of those parts that are treated externally. Special or anatomico-topographical surgery has to do with the surgical diseases of the different parts of the body, at the same time taking into consideration the most varied tissues and organs according to their locality. While, for instance, we only speak here of wounds in general, of their mode of healing, and of their general treatment, in special surgery we discuss wounds of the head, chest, and abdomen, and we then have especially to attend to the simultaneous participation in the injury of the skin, the bones, and the viscera. Were it possible to pursue one's surgical studies for many years at one of the larger hospitals, and at the same time to combine with them an accurate clinical examination of each individual case together with persevering study at home, it might perhaps be unnecessary to treat of special surgery systematically in lectures delivered for the purpose. But as there is a considerable number of surgical diseases which even in the largest hospitals are never seen in the course of many years, a knowledge of which, however, is absolutely necessary to the physician, lectures on special surgery are by no means superfluous when they are brief and concise. One often hears it said, Why should I hear lectures on special surgery and pathology? I can read them up far more comfortably in my own room! That may be the case certainly, but unfortunately it is only too seldom done, or not until the final sessions, when the examination threatens. This reasoning is also in other respects false; the *viva vox* of the teacher, as old Langenbeck in Göttingen used to say (and he had, in truth, a *viva vox* in the highest signification of the word), the winged words of the teacher always are, or at least ought to be, more impressive and effectually stimulating than what we read; and what must render lectures on practical surgery and medicine part-

cularly valuable for you are the demonstrations of diagrams, preparations, experiments, &c., which accompany them. I set the greatest value on demonstrations in connection with medical instruction, as I well know from my own experience that this kind of instruction is the most stimulating to the attention and the most permanent. Besides these lectures on general and special surgery you will have to go through the operative course on the dead body; this can be put off to the final sessions. I always liked students to take this surgical operative course in the sixth or seventh session at the same time as the special surgery, so that I could give them opportunities of performing some operations, occasionally amputations, in the hospital, under my superintendence. It gives confidence in your future practice if you have already performed operations on the living subject during the period you were engaged in study.

It is a great advantage in the smaller universities that there the teacher may become well acquainted with every pupil and know what he can trust to the skill of any one individual. This is unfortunately impracticable in the larger hospitals on account of the circumstance of their size. Avoid the large universities, therefore, at the commencement of your clinical studies. Attend them rather in the later period of your apprenticeship, and when you are already in practice return later from time to time and spend a few weeks in them.

After hearing general surgery you commence attendance in the surgical wards of the hospital, in order that in the seventh and eighth sessions you may as a practitioner publicly give an account to yourself of your knowledge in special cases and accustom yourself to concentrate your knowledge rapidly, to learn to distinguish the important from the unimportant, and, above all, to learn how to apply it in practice. By this means you will be enabled to recognise the flaws in your knowledge, and by persevering industry at home be able to fill in the gaps. If you have in this manner got through the legal period of study, passed the examinations and enlarged your medical horizon for a few months or a year at various large hospitals either at home or abroad, you will then be so far educated that you will be able to form a correct judgment of surgical cases occurring in practice. If, however, you wish to qualify yourself as a special surgeon and operator you are still far from your ob you must then repeatedly practise operating on t

as assistant for from two to four years in the surgical wards of a hospital, study surgical monographs indefatigably, write out cases industriously, &c.; in short, go through the whole of the practical course from the very beginning. You must also thoroughly understand the hospital service and the duties of the nurses; in fact, you must practically learn everything, even the most insignificant things, that in any way pertain to the patients, and even learn to be able to do them yourself occasionally, so that you may obtain a complete command over the medical staff entrusted to you. You see that there is much to be done, much to be learnt, but with perseverance and industry you will accomplish it all. Perseverance and industry, however, are necessary for the study of medicine. "Student" is derived from "to study," and you must study diligently. The teacher will call your attention to what he considers the most necessary; he may stimulate your energies in various directions; the positive that he gives you, you can take home in black and white, but in order that that positive may quicken and bear fruit in you, that it may become your own intellectual property, that you can only bring to pass by your own mental work; this mental work is the true study.

If you simply maintain an attitude of passive receptivity you may certainly gradually acquire the reputation of being a very learned man, but unless you have the power of reproducing and giving life to your knowledge you will never make a good "medical practitioner." Let what you observe penetrate your inmost soul, let it so warm and replenish you that your thoughts constantly refer to it, and then you will find true pleasure and delight in your intellectual labours. How strikingly Goethe observes in a letter to Schiller, "Pleasure, delight, interest in things, these are the only realities; all else is vanity and disappointment."

LECTURE II.

CHAPTER I.

SIMPLE INCISED WOUNDS OF THE SOFT PARTS.

Mode of origin and appearance of these wounds.—Various forms of incised wounds.—Symptoms during and immediately after the act of wounding: pain, hæmorrhage.—Different kinds of hæmorrhage: arterial, venous.—Entrance of air through wounds in veins.—Parenchymatous hæmorrhage.—Hæmorrhagic diathesis.—Hæmorrhage from the pharynx and rectum.—General consequences of severe hæmorrhage.

The proper treatment of wounds is to be regarded as the first and most requisite qualification for the surgeon, not merely on account of the extreme frequency of their occurrence, but also because in operating we so often purposely make wounds, and not rarely under circumstances in which the operation is for a complaint that can hardly be considered dangerous to life. We are therefore so far responsible for the healing of wounds, as, according to experience in general, we are enabled to form a judgment as to the danger of an injury. We will now commence with the discussion of *incised wounds*.

Injuries produced by strokes with sharp knives, scissors, sabres, rapiers or axes, present the characters of clean-cut wounds. Such wounds are mostly known by their sharply defined regular edges, in which we see the smooth-cut surfaces of the unaltered tissues. Should the above-named instruments be blunt, they may still cause tolerably clean incised wounds, if the blow was given rapidly, whilst if slowly, the penetration of the tissues would give the cut edges a rough contused appearance; occasionally the kind of injury only becomes apparent during the process of healing, for wounds caused by the rapid movement of a sharp instrument heal more easily and

quickly, for reasons to be hereafter stated, than those caused by a blunt, slowly penetrating knife, scissors, sword, or such-like instrument. It is but rarely that a completely blunt body causes a wound having the same characters as an incised wound. This may happen from the skin splitting from the force of a blunt body, particularly such portions of it as lie close to the bone. You will not unfrequently observe, for instance, that scalp-wounds have quite the appearance of incised wounds, though caused by a blow from a blunt body, or from striking the head against a stone or beam, or something of that kind. Similar clean-cut lacerated wounds of the skin occur on the hand, chiefly on its palmar surface. Sharp edges of bone may also divide the skin from within outwards, making it look as if it had been cut, as, for instance, when any one falls on the crista tibiæ, and the skin is cut through by it from within. We can easily understand, too, that pointed splinters of bone penetrating the skin may also cause wounds with clean-cut edges. Finally, the point of exit of a gunshot wound, that is, of the course of the bullet through the part struck, may under certain circumstances be a sharply defined slit-like aperture.

A knowledge of these circumstances is of importance, because you may by chance be asked by a judge if a certain wound in question was caused in such and such a manner, with this or that instrument, and your reply may give a decided turn to the evidence in a criminal case.

We have hitherto considered such wounds only as are caused by blows or strokes. But by repeated cuts the edges of a wound may get a jagged appearance, and in this manner the conditions for its healing be essentially changed; of such wounds we will say nothing at present, they must be classed with contused wounds in regard to their healing and treatment, unless by paring their jagged edges they can be artificially converted into simple incised wounds. The direction in which a cutting instrument is held in relation to the surface of the body at the time of its penetration makes on the whole but little difference, if it be not so slanting that portions of the soft parts are cut off in the form of more or less thick flaps. In these *flap-wounds*, or *sliced wounds*, the breadth of the bridge connecting the half-separated portion with the body is of great importance, as it depends upon that whether any circulation of the blood can still continue in the flap, or whether it has entirely ceased and the severed portion must be regarded as dead. Cuts are the prin-

cipal cause of these flap-wounds, but they are not uncommonly due to a tear or laceration; they occur frequently on the head, where a too violent tug at the hair may tear away a piece of the scalp. In other cases a portion of the soft parts may be completely cut out; we then have a wound with loss of substance. By penetrating wounds we understand those by which one of the three great cavities of the body or a joint is laid open; they arise most commonly from a stab or a shot, and may be complicated by injury to the viscera or bones. By the general terms longitudinal or diagonal wounds we refer, as may be readily understood, to the long or transverse axis of the body, head, or extremities. Diagonal or longitudinal wounds of the muscles, sinews, vessels, or nerves, are naturally such as divide the fibres in a transverse or longitudinal direction.

In a person wounded the symptoms more or less immediately caused by the act of wounding are pain, hæmorrhage, and gaping of the wound.

As all the tissues, not excepting the epithelial and epidermic, are supplied with sensory nerves, pain is at once caused by the injury.

This pain varies considerably according to the supply of nerves in the part injured, and according to the susceptibility of the individual to the sensation of pain. The fingers, lips, tongue, the neighbourhood of the nipple, the external genitals, and the anal region, are looked upon as the most sensitive parts. The nature of the pain felt from a wound, as for instance of the finger, is probably familiar to each of you from personal experience.

Cuts of the skin are decidedly the most painful, an injury to the muscles or sinews is far less so; injuries of the bones are always extremely painful, as you may convince yourselves by inquiring of any one who has suffered from a broken bone; and we are informed that when amputations were performed without chloroform the sawing of the bone was the most painful part of the operation. The intestinal mucous membrane, as we may occasionally observe in men and animals, is hardly at all sensitive if irritated; and the portio vaginalis uteri is almost insensible to mechanical and chemical irritants; sometimes even the application of the actual cautery, which is used to cure certain affections of this part, is not felt by women.

It appears that very few if any sensory nerves are associated with the nerves which need a specific irritation, such as those of the special senses.

The relation between the sentient tactile nerves of the skin and the sensory nerves, if there be any essential difference between them, is still an undetermined question. In the nose and tongue we certainly have sentient and sensory nerves lying side by side, so that in both organs there may be a sensation of pain as well as the special sense belonging to each organ. On cutting through the nervus opticus there is perception of light, but no pain to speak of. We have no recorded observations as to direct injury of the auditory nerve.

Although the white substance of the brain contains many nerves, it is yet without feeling, as may be seen in many severe injuries of the head.

The division of nerves of sensation or of compound nerve-trunks is at any rate the most painful of all injuries; the laceration of the dental nerve in tooth extraction is an instance that may be familiar to many of you; the division of thick nerve-trunks must cause overpowering pain.

Sensitiveness to pain seems to vary somewhat in different individuals. You must not, however, confuse this with the external expressions of pain as shown in various degrees, and with the psychical power to stifle these expressions, or at least to retain them within bounds; this, anyhow, depends on the strength of will of the individual as well as on the temperament. Men of active temperament express pain, as well as all other sensations, more vividly than phlegmatic men. Most men say that the crying out, as well as the instinctive firm tension of all the muscles, especially of the masticatory muscles, biting or grinding the teeth together, &c., renders the pain more endurable. Personally I have never found that it allayed it in any way, and look on it as imagination on the part of patients. Strong will in the patient may do much to suppress all signs of pain. I have a vivid remembrance of a woman in the Göttingen Hospital, at the time I was a student there, who had the whole of the upper jaw removed, on account of a malignant tumour, without chloroform, during which severe and excessively painful operation, in which many branches of the nervus trigeminus were cut through, she did not utter a sound of pain. Women, as a rule, bear pain better and more patiently than men. But the exercise of psychical strength required, not unfrequently causes subsequent fainting or a high degree of physical and psychical relaxation, of longer or shorter duration. I have seen

strong men, of determined will, who suppressed every indication of suffering, though the pain was severe, but soon afterwards dropped senseless. But, as I before remarked, I believe that many men feel pain far less intensely than others. You will most probably meet with people who, without any exercise of an energetic will, show so little sign of pain, after painful injuries, that we can only suppose that they actually feel pain less acutely than other people; I have mostly observed this in dull stupid men of lax fibre, in whom all the nervous symptoms following the injury were also remarkably slight. Sudden fright occasionally causes temporary anæsthesia; timid men, but especially children, may be so stunned by suddenly shouting at them, that we are enabled to perform small operations quickly, which otherwise they would never have consented to.

The quicker a wound is made and the sharper the knife, the less is the pain; so that, in the interest of patients, we lay great stress, and rightly too, upon using the knife with certainty and rapidity in all small and large operations, particularly in making the incisions in the skin.

The sensation in a wound immediately after an injury is a peculiar burning one; we can hardly call it anything else than the feeling of being wounded, smarting. Only when a small or large nerve is compressed by something or another in the wound, or is lacerated or in any way irritated, we get, immediately after the injury, severe pains of a truly neuralgic character, which if they do not soon cease spontaneously, must be allayed by removal of the local causes after careful examination; or if this cannot be done, or is ineffectual, by the administration of narcotic remedies, otherwise the patient may get into a highly excitable state, which may be kept up until it increase to maniacal delirium. At the present day inhalations of chloroform are universally employed in order to avoid pain in operations. The mode of using this remedy, and the prophylaxis and treatment of the dangers caused by chloroform, you will learn more quickly in the hospitals, and afterwards remember better than if I were to give you a detailed account of it here.

In the lectures on operative surgery this will be more fully discussed; I will only just mention that recently sulphuric æther has again come more into use than during the ten previous years, during which time the number of deaths from chloroform had increased owing to its enormously extended employment. At

present I use exclusively as an anæsthetic a mixture of three parts of chloroform with one part of sulphuric æther and one part of absolute alcohol, and I have an impression that the narcotism produced is less dangerous than that from chloroform alone. In England during the last few years bichloride of methylene has been much used and warmly recommended, particularly by Spencer Wells; it is said to act as quickly as chloroform and to be less dangerous. Local anæsthetics which are intended to numb pain temporarily in the part to be operated upon, as, for instance, by the application of a mixture of ice with saltpetre or salt, have generally been quickly given up again, or, rather, have never been extensively used. More recently these attempts have awakened a more active interest, for it seemed as if at length a really efficacious method for producing local anæsthesia had been discovered. An English physician, Richardson, has constructed a small apparatus by means of which a spray of æther can be blown against the skin, whereby, after a time, such an amount of cold is generated at the spot on which the spray is directed that it is deprived of all sensation. After receiving this æther from England I satisfied myself of the perfection of its action. In fact, in a few seconds the skin becomes as white as chalk, and absolutely without sensation to the extent of this whiteness, but this effect hardly extends through a moderately thick cutis; and if, without further consideration, the spraying be continued against the cut surface until this is completely anæsthetised, in consequence of the intense cold we have, on the one hand, the misfortune that we can no longer distinguish the hard frozen tissues from each other, and, on the other hand, the knife becomes covered with such a coating of ice that it will no longer cut. Consequently local anæsthesia, even in this perfected form, can only be employed advantageously for patients in a few minor operations. My former apprehension, that the subsequent process of healing would be essentially interfered with, in consequence of the application of such intense cold to the tissues, has proved to be incorrect.

For allaying the pain and as a hypnotic immediately after extensive injuries and operations there is nothing better than a dose of about one third of a grain of muriate of morphia; the patient is quieted, and though he may not always get sleep he at any rate feels less pain from his wounds. Morphia can also be used in the form of subcutaneous injections. If with a very fine syringe, to

which a pointed lancet-shaped canula is so attached that it can be easily pierced through the skin, we inject a solution containing one sixth to one third of a grain of muriate of morphia, this produces its narcotic effect at first locally on the nerves irrigated by it, and afterwards on the brain as the morphia solution becomes absorbed into the blood. This mode of using morphia has latterly been most highly commended; such an injection is generally made either directly before or after an operation, or after an accidental injury, usually in the immediate neighbourhood of the injured part, by which means the pain is at once relieved. Most of the syringes in general use for subcutaneous injection contain about fifteen minims[1] of fluid; we prescribe for patients, when ignorant as to how they are affected by morphia, ten parts of muriate of morphia to a thousand parts of distilled water, and inject a syringe full of the solution; many individuals require twice this quantity or more in order to obtain the desired soothing effect. If we prefer injecting only half a syringe full each time, so as not to have to order a repetition of the medicine too frequently, we must double the quantity of morphia. In larger quantities than 5 per cent. this salt of morphia only dissolves in warm water; the injection of large quantities of fluid as well as of too concentrated solutions causes pain to patients. Particular attention must be paid to the cleanliness and careful washing of the syringes.

Quite recently hydrate of chloral in doses of 3·00—5·00 grammes (in half or a whole glass of water) has been used internally as an anæsthetic; its narcotic effect was discovered by Liebreich in 1869. The action of this remedy is chiefly intensely hypnotic; it is, however, rather uncertain; it cannot supply the place of chloroform, but as a new narcotic it is a decidedly valuable acquisition to our therapeutic treasury. Finally, we can employ cold locally as a remedy for the relief of pain in the form of cold compresses or bladders of ice applied to the wound; we shall speak of this again when we come to the treatment of wounds.

In a clean cut or punctured wound the second immediate symptom is hæmorrhage, the quantity of which depends on the number, size, and kind of vessels divided. We speak here solely of hæmorrhage from tissues that were perfectly sound before the occurrence of the injury, and we distinguish capillary, parenchy-

[1] One gramme is equal to about fifteen grains.

matous, arterial, and venous hæmorrhage; these must be considered separately.

Different parts of the body, as is well knowu, vary considerably as to their supply of blood-vessels, the greatest differences being chiefly in respect to the number and size of the capillaries. In a given portion of the skin there are fewer and smaller capillaries than in a portion of equal size in most of the mucous membranes; the skin, too, contains more elastic tissue and muscles as well, so that (as we feel and see in the cold and in the so-called goose-skin) the vessels are more easily compressed than in the mucous membranes, which are deficient in elastic and muscular tissue; simple wounds of the skin therefore bleed less than wounds of mucous membranes. If the tissue be healthy, capillary hæmorrhage will cease of itself from the compression of the open mouths of the vessels by the contraction of the injured tissue. But in diseased parts, which cannot contract, bleeding from the dilated capillaries may be very considerable.

Hæmorrhage from arteries may be easily recognised, partly because the blood spirts out in a jet-like stream, in which the rhythmical contractions of the heart are distinctly perceptible, and partly because the blood effused has a bright-red colour. This bright-red colour of the blood, however, changes to a very dark hue when there is deficient respiration; so that in operations about the neck, for instance, performed on account of danger of suffocation, and in very deep narcotism from chloroform, quite dark, almost black blood may spirt out of the arteries.

The quantity of blood effused depends either upon the diameter of the completely divided artery or upon the size of the opening in its wall. You must not, however, imagine that the size of the jet of blood from an artery corresponds exactly to the diameter of the vessel; it is usually much smaller, because an artery contracts at the divided part and so diminishes the size of the opening; the large arteries, however, as the aorta, carotid, femoral and axillary arteries, possessing but few muscular fibres, show hardly any perceptible contraction, at least in the calibre of the vessels. In very small arteries this contraction of the divided vessel has such an effect that occasionally, owing to the obstruction to the flow of the blood caused by the increased friction, the stream neither spirts nor pulsates; and this friction in the smaller arteries may be so considerable that the flow of blood soon becomes excessively slow

and impeded towards the divided ends, until at length it rapidly coagulates and the bleeding ceases of itself. The smaller the diameter of the arteries, owing to the diminution of the total quantity of blood in the body, the more quickly the bleeding ceases without its being necessary to arrest it artificially. Hereafter you will frequently have opportunities in the hospitals of observing how strongly the blood spouts out at the commencement of one of the larger operations, and how towards its termination the hæmorrhage is considerably less, even when the arteries divided are absolutely larger than those cut through at first. Decrease in the quantity of blood in the body may thus lead to spontaneous arrest of hæmorrhage, though at the same time the weaker contractions of the heart must also be taken into consideration. In fact, in internal hæmorrhages which are inaccessible to direct artificial aid we make use of a rapid abstraction of blood from the veins of the arm (venesection) as a hæmostatic; the artificial production of the condition of general anæmia, (naturally only done in cases in which the internal hæmorrhage has not already caused it) is in such cases looked upon as a remedy for internal hæmorrhage, however paradoxical this may appear at first sight. Hæmorrhage from cut wounds of the great arterial trunks of the body, neck and extremities, is always so serious that artificial arrest of the hæmorrhage is absolutely necessary unless the opening in the arterial wall is extremely small. If, however, an arterial trunk in one of the extremities be lacerated without any wound of the skin, then certainly, owing to the pressure from the surrounding soft parts, the stream of blood from the artery may be checked; such injuries give rise later to further after-consequences, to which we shall direct your attention on another occasion.

Bleeding from the veins is characterised by the continuous flow of dark blood. This is chiefly the case in veins of small and medium calibre. It is rarely very profuse, so that in order to obtain a sufficient quantity of blood when bleeding from the subcutaneous veins at the bend of the elbow it is necessary to check by compression the flow of blood towards the heart. Were this not done only a little blood would flow from these veins on their being punctured; the further bleeding, however, would cease spontaneously, unless somewhat kept up by muscular action. This is chiefly because the thin walls of the veins collapse instead of gaping like a divided artery. Owing to the valves, the blood does not easily flow

back from the cardiac extremity of a divided vein as long as there is no insufficiency of the valves; we very rarely have to deal with valveless veins, such as those of the portal system.

Hæmorrhage from the large venous trunks is always most dangerous. Hæmorrhage from the axillary, femoral, subclavian or internal jugular veins is in most cases fatal if assistance be not speedily rendered; a wound of either of the innominate veins may be looked upon as absolutely mortal. Blood does not flow in a continuous stream from these great venous trunks, but shows very decidedly the influence of the respiration on the circulation. I have several times seen the internal jugular vein wounded in operations on the neck; during inspiration the vessel collapsed to such an extent that it might have been mistaken for a band of fibrous tissue, while during expiration black blood welled out as if from a spring, or rather like the bubbling up of water from an artesian well.

In veins which are contiguous to the heart there is, besides the excessive and rapid loss of blood, another circumstance that heightens the danger considerably, namely, that during a deep inspiration, when the blood regurgitates towards the heart, air occasionally enters the vein with an audible gurgling sound and is carried into the heart; instant death may be thus caused, but such is not necessarily always the case. I cannot here enter more fully into this extremely remarkable phenomenon, which, as regards its physiological action, does not as yet appear to me to have been satisfactorily explained. You will again have your attention called to this in books and lectures on operative surgery. You will also be told that on the opening of a large vein in the neck or axilla a gurgling noise is heard, and the patient immediately becomes unconscious, and that only in a few cases can he be again brought to life by the instantaneous employment of artificial respiration and other restorative remedies. The probability is that, owing to the air-bubbles penetrating as far as the medium-sized branches of the pulmonary artery and lodging there, the further progress of the blood to the vessels of the lung is suddenly checked; owing to the stoppage of the pulmonary circulation the flow of blood to the left side of the heart ceases; the entire aortic system receives no blood, consequently the brain gets none; sudden and total cerebral anæmia is thus most likely the immediate cause of the sudden death. I have never experienced anything similar to this, although I have known air enter the internal jugular vein and seen frothy blood

escape; this had no perceptible effect on the general condition of the patient. It appears that animals vary considerably as to their relative susceptibility in respect to the entrance of air into the vessels; if with a syringe you pump only a small quantity of air into the jugular vein of a rabbit it soon dies, while you may sometimes pump several syringefuls of air into a dog without observing any effect.

Besides the varieties already mentioned, we distinguish the so-called *parenchymatous hæmorrhage,* which is sometimes incorrectly identified with bleeding from the capillaries. In the normal tissues of an otherwise healthy body parenchymatous hæmorrhage does not come from the capillaries, but from a large number of small arteries and veins, which owing to certain circumstances do not contract and withdraw themselves into the surrounding tissue, and are consequently not compressed by them. Hæmorrhage from the corpus cavernosum penis is an instance of this kind of parenchymatous hæmorrhage, and it occurs similarly from the female genitals, in the perineal and anal region, and in the tongue and spongy bones. These parenchymatous hæmorrhages are very common in diseased tissues, and they not unfrequently occur as so-called *secondary hæmorrhages* after injuries and operations; of this we will speak later on.

One thing should be mentioned here, and it is that, according to the most authentic accounts, there are people who bleed so freely from every small insignificant wound that they may bleed to death from a scratch on the skin or from the vessel in the dental pulp after extraction of a tooth. This constitutional disease is called the hæmorrhagic diathesis (hæmophilia), and people subject to it are called in Germany bleeders (hæmophilists), from the Greek words αἷμα and φίλος. The essential nature of this complaint consists, probably, in an abnormal tenuity of the walls of the arteries, which is, in most cases, congenital, but may, perhaps, gradually arise from pathological degeneration, with atrophy of the coats of the vessels. Conditions of abnormal pressure arising from the relatively too great narrowness of the large arterial branches may occasionally be the cause of such apparently enigmatical hæmorrhages as those to which Virchow has latterly drawn particular attention. This dreadful malady is often hereditary in certain families, especially among the male members; women are less frequently afflicted with it. Not wounds alone cause bleeding in such

people, but simple pressure even may give rise to subcutaneous hæmorrhage; bleeding of a fatal character may also occur spontaneously, as from the mucous membrane of the stomach or bladder. It is not even after the more serious wounds, where medical assistance has been rendered immediately or within a short time of the occurrence, but principally after slight injuries. that in such people these continuous hæmorrhages take place that are so difficult to stop, which, as already remarked, points partly to diminished contractility or complete absence of muscular tissue in the vessels, and partly to deficient coagulability of the blood. The latter has certainly not been confirmed from observation of the blood effused, as, in those cases where attention was directed to it, it coagulated just like the blood of a healthy man. That the state of the blood must be taken into consideration with respect to this disposition to hæmorrhage, is clear from the circumstance that leucocythœmic individuals (in whom the number of white blood corpuscles is considerably increased, while that of the red is diminished) often bleed profusely from small wounds.

A rapid and excessive loss of blood soon causes very perceptible changes in the whole body. The face, and particularly the lips quickly become very pale, and the latter turn bluish; the pulse becomes smaller and at first diminishes somewhat in frequency. The temperature falls most strikingly at the extremities; the patient readily faints, especially if he sits upright, he turns giddy, he has a tendency to vomit, there are flashes before his eyes, singing in the ears, all things seem to swim round him, he collects all his strength to hold himself up, then all sense is lost, and finally he swoons away. We explain these symptoms of fainting by supposing rapid cerebral anæmia. This soon passes off in the horizontal position; people often faint after a very small loss of blood, as a rule, more from horror and disgust at the sight of blood than from loss of power. One single fainting attack of this kind is thus no index as to the quantity of blood lost, the patient soon comes to himself again. Should the hæmorrhage continue, the following symptoms sooner or later make their appearance. The face becomes more and more blanched and wax-like in appearance, the lips of a clear, pale, blue colour, the eyes dim and glassy, the temperature sinks still lower, the pulse gets smaller, thread-like, and extremely frequent, respiration incomplete, vomiting sets in, the patient faints repeatedly, gets constantly weaker and more anxious

and restless, at length persistently unconscious, and finally there are convulsive twitchings of the arms and legs, which are renewed on the slightest irritation, as by the prick of a needle for instance; this condition may pass on to death. Great dyspnœa, gasping for breath and at the same time a subjective feeling of heat with great restlessness are among the worst symptoms; but even then we must never despair, as we may still often be of service, although life is apparently extinct. Young women especially can bear enormous losses of blood without immediate danger to life; you will have opportunities later for observing this in the lying-in hospital; children and old people least of all bear much loss of blood. In very old people great loss of blood, though not immediately fatal, may result in an incurable collapse, terminating in death days or weeks afterwards; this admits of a very easy explanation; the amount of blood lost is at first replaced by serum, and as the formation of blood-corpuscles probably takes place very slowly in old people, the greatly diluted blood is not sufficient to nourish their tissues, which at that time of life are extremely torpid in their interchange of materials. Should the patient come to after a severe hæmorrhage, he chiefly feels excessive thirst, as though the body were dried up, and the vessels of the intestinal canal absorb greedily the quantities of water that are drunk; in strong healthy men the cellular constituents of the blood are soon replaced (from what sources we certainly do not exactly know); after a few days we observe very little of the former anæmia in an otherwise healthy, strong, and young individual; and he also soon feels nothing of the former exhaustion of his strength.

LECTURE III.

Treatment of hæmorrhage : (1). *Ligature and transfixion of arteries. Torsion.*—(2) *Compression, compression with the fingers, choice of places for compression of the larger arteries.—Tourniquet. Acupressure.—Bandaging.—Application of the tampon.*—(3) *Styptics.—General treatment of suddenly-occurring anæmia.—Transfusion.*

You now know, gentlemen, the different varieties of hæmorrhage. Now, what means have we for arresting hæmorrhage more or less severe? The number of remedies is great, and yet we only employ a few of them, those alone which are the most certain. Here you have at once a field of surgical therapeutics, the requirements of which depend on assistance rendered quickly and with certainty, so that the result may not be doubtful. But the employment of these remedies requires practice; coolness, quiet, absolute certainty as regards operative skill, and presence of mind, are the first requisites in cases of dangerous hæmorrhage. In such situations the surgeon may show what he is capable of.

Remedies for stopping the effusion of blood are divided into three principal classes: (1.) The occlusion of the vessel by tying or twisting it: ligature or tying, and torsion; (2.) compression; (3.) remedies, which cause rapid coagulation of the blood, styptics (from στύφω, to contract, to harden).

The ligature may be used in three different ways, either by applying a ligature to the isolated bleeding vessel, or by transfixing, that is, surrounding the vessel, together with the neighbouring soft parts, or by applying a ligature in the continuity of the vessel, that is, tying the artery at some distance from the wound.

These various modes of ligation are almost entirely used for arresting arterial hæmorrhage. The ligature is rarely required for venous hæmorrhage; only in the very large venous trunks is it

occasionally indicated; we avoid it however, if anyhow possible, as the consequences may be dangerous: later on we will inquire in what the danger consists, and at present only speak of the ligature of arteries.

Let us take the most simple case; one of the smaller arteries is spirting in a wound, you first take a pair of so-called sliding forceps, seize the artery transversely if you can, and as much isolated as possible, then push home the slider of the forceps and the bleeding is completely stopped. These sliding forceps are best made of German silver, as this metal rusts less easily than iron. There are many different varieties of forceps, which all have the one thing in common, that, when they are closed they remain fixed in this position; the mechanical means by which this closure is effected, vary greatly; the simpler the mechanism the better. It is interesting to examine the various phases of development that this instrument has passed through since the time of Ambrose Paré, before attaining its present state of simplicity and perfection. More recently small spring clips have been occasionally used to compress bleeding arteries; they are certainly very serviceable if strongly made. Besides these forceps, one can also make use of small curved, sharp hooks (Bromfield's artery tenaculum) in order to draw the artery forwards, but this is far less practical, as the blood naturally continues spirting during the subsequent application of the ligature.

Having seized the artery securely, the next thing is to make the closure effectually permanent, this is done by the ligature. Convince yourself, however, beforehand, that you have not included some branch of a nerve with it, as the simultaneous ligature of a nerve may not only cause severe continuous pain but dangerous constitutional nervous symptoms as well. For tying arteries we use silk thread, twine or catgut of varying thickness according to the size of the arteries; the threads must be good, strong ones, that they may not break when tightly tied.

The forceps, which remain attached to the extremity of the artery, should be slightly raised, and the thread is best applied round the artery from below, making first a simple knot and tying it tightly just in front of the branches of the forceps, and then securing it with a second knot. Now loosen the forceps, and if the ligature is properly applied, the bleeding must cease. The knot must be fastened firmly and securely by pushing the ends of the thread forward and stretching them steadily with the points of both fore-

fingers. This is especially necessary when very deep-seated arteries have to be tied. If the threads are good, two simple knots placed one over the other are sufficient. You should practise these little manipulations beforehand on the dead body or on living animals. If the ligature holds securely, you must, if you have used silk or twine, cut the one end short off and carry the other end out of the wound by the shortest way; after six to ten days, you can as a rule withdraw these threads from the wound. In wounds which you intend to unite completely and by first intention, it is best to use catgut (gut-strings, soaked in oil to render them supple); the knots and loops become gradually absorbed, and it is only very rarely that they are thrown off later by suppuration.

We cannot always succeed in isolating the spirting artery so as to be able to seize and tie it; occasionally it withdraws itself so strongly into the tissue, chiefly into the muscles and thickened cellular tissue, that it is impossible to obtain a hold of it detached from the surrounding parts. Under such circumstances it is difficult to apply the ligature securely; you are then very apt to include the points of the forceps in the ligature, as you cannot push the thread far enough forward. In this case the proper plan is to transfix the artery. After having drawn the bleeding part forward with forceps or a hook, you take a strong semicircularly curved needle held in a needle-holder, thrust it in close to and on one or the other side of the bleeding vessel so as to surround it from below, carry the needle out, draw the thread through with it and fasten the knot so as to encircle the entire end of the artery; then tie it very tightly as we have described above; in this manner some of the adjacent tissue will be included with the artery, and the mouth of the vessel closed at the same time. This transfixion is only to be looked upon as an exceptional proceeding, for the strangulated tissue either perishes or decomposes in the wound if the ligature has completely destroyed vitality in the tissues, or if the ligature has been imperfect, it sets up intense inflammation; both may complicate the process of healing. That we must guard against tying any visible branch of a nerve lying near the bleeding vessel is a matter of course. Middeldorpf's method of percutaneous transfixion is more summary still; you take a large strongly curved needle and simply thrust it, as in a case of hæmorrhage from the radial artery for instance, on the cardiac side of the bleeding spot, deeply through the skin transversely to and beneath the artery, and

bring it out on the other side; the thread moderately firmly tied, compresses the artery together with many other parts; the thread remains for two or three days and is then removed. I cannot, however, recommend this method to you; it should only be used in cases of exigency, and merely as a provisional remedy for arresting hæmorrhage.

As long as the bleeding arteries are visible in the wound, the first thing to be done is to apply the ligature; but in those cases where the arteries of the periosteum spirt out blood the application of the ligature may be impossible, it is just as little applicable in spirting arteries of the bone; other methods are employed here, chiefly compression.

If you have to deal with very large bleeding arteries, the proceeding is exactly the same, only you must be doubly careful to isolate the artery; you must, after seizing the bleeding end scrape back the surrounding tissue by the aid of a small scalpel or anatomical forceps, and then tie it most carefully and accurately; in most arteries you must tie both the cardiac and distal ends if they lie exposed in the wound, for the anastomosis in the arterial system is always sufficiently extensive to cause bleeding from the distal end through the medium of the collateral branches; if not immediately, at any rate later.

It may happen that the wound from which severe hæmorrhage takes place, is only very small, as from a stab or gun-shot wound. Guided by your anatomical knowledge you should know what large vessel has been injured by the wound in question. If you are convinced by the severity of the bleeding that the ligature is the only certain remedy to stop it, you then have the following alternatives:—Either to enlarge the wound, to search for the vessel by careful clean dissection, while it is at the same time compressed above the wound, the limb having been beforehand emptied of blood by Esmarch's bandaging (of which later), and then to tie the ends of the divided artery, or while the bleeding vessel is compressed in the wound you search above it for the cardiac portion of the trunk of the vessel of that extremity and apply the ligature in its continuity. Accurate anatomical knowledge as to the situation of the arteries and practice are absolutely necessary in both methods of proceeding. Which of these these two methods you choose, will depend upon which is likely to effect its purpose most quickly, and to cause the least additional injury. If you think that you can

easily expose the artery in the wound without causing any important injury to neighbouring parts, choose this method as absolutely certain; but if you consider this very difficult, if the artery, for instance, at the part injured, lies very deeply beneath layers of muscle and fascia, particularly in very muscular or very fat people, then apply the ligature in the orthodox manner to the trunk of the vessel in its continuity above the wound (towards the heart).

I shall not here enter upon the subject as to the choice of places for tying the vessels, these have for many, many years been thoroughly tested and universally accepted on theoretical and practical grounds. In operative surgery, in the manuals on surgical anatomy, and especially in the course on operative surgery you will be instructed on these points, but above all things you must exercise yourself in the practice of being able to find the arteries with certainty, of exposing them neatly, and of tying them according to the rules of art; at the same time you cannot accustom yourself to too much pedantry and uniform technicality.

Although the great value of the ligature is acknowledged by all surgeons of the present day, people have never ceased trying to discover simpler, and at the same time equally certain methods. I will here merely mention torsion of the bleeding arterial extremities as one method, which is employed to close the vessels mechanically and safely without a ligature until occlusion is effected by their walls growing together. With strong, very accurately-closing, sliding-forceps, you seize the spirting bloodvessel isolated from the surrounding parts, either transversely or in its longitudinal axis, draw it forwards for about half an inch and then twist the forceps and with it the artery about five or six times on its longitudinal axis; I generally draw the vessel as far forward as practicable and then twist it till it breaks off. In this manner I have twisted bleeding arteries from the size of the smallest up to that of the brachial artery so effectually that the hæmorrhage was quite safely arrested. Should branches be given off just above the bleeding end of an artery, we find that the vessel is then not sufficiently moveable to employ torsion with certainty; for this reason I have only once succeeded in torsion of the femoral artery.

(2.) *Compression.*—Pressure with the finger on the bleeding vessel is so simple and so convenient a method of arresting hæmorrhage, if method it can be called, that we can only wonder that the

laity do not at once resort to it; it is a matter of instinct with anyone who has been present at a few operations to immediately place the finger in contact with the bleeding vessel and hold it there. And yet how rarely do we find that people think of this most simple remedy in a case of accidental wounding. They prefer employing all sorts of useless domestic remedies, daub the wound over with cobweb, hairs, urine and every possible kind of filth, or fetch some old woman to staunch the bleeding with a charm. And no one present chances to think of compressing the wound! The object of methodical compression is twofold, provisional and permanent.

Provisional compression, which is only made use of until it is decided how the hæmorrhage in the case in question may most certainly be definitively arrested, is managed either by pressing with the finger the bleeding vessel in the wound firmly against a bone, the edges of the wound in the meantime being pressed firmly against each other; or by compressing the cardiac portion of the trunk of the artery against the bone at a greater or less distance from the wound; the first, as we have already stated, if we wish to tie the trunk, the latter if it is desired to tie the bleeding end of the artery or to examine the wound more accurately.

Where shall we compress the arterial trunks and how shall we most effectually carry it out? To compress the right carotid artery you place yourself behind the patient, take the second, third and fourth fingers of the right hand, place them together and press the points of the fingers somewhere about the middle of the neck at the anterior border of the sterno-cleido-mastoid muscle firmly against the vertebral column, at the same time clasping the nape of the neck with the thumb, and with the left hand bending the patient's head slightly towards the wounded side and somewhat backwards. You will then plainly feel the pulsation of the carotid artery. Firm pressure is here very decidedly painful for the patient, as we cannot avoid pressing upon the vagus nerve and by the deep pressure of the fingers so much tension of the parts is produced that it affects the larynx and trachea. On account of the free anastomosis between the carotid arteries, one-sided compression of a carotid for the arrest of hæmorrhage from the arteries of the head or face is not very effectual, and to compress with perfect certainty on both sides takes up so much room, that in most cases we have to be contented with a diminution of the arterial volume by incomplete compression.

Compression of both carotids is always a painful and alarming manipulation for the patient, chiefly owing to the strong indirect pressure thereby exercised on the larynx and trachea, consequently it is seldom made use of. Compression of the subclavian artery may often be necessary, particularly in wounds of this artery in Mohrenheim's fossa and in the axilla. In this operation too it is best to stand behind the recumbent or half-sitting patient, then with your left hand incline the head of the patient towards the wounded side (we will suppose it to be the right) and immediately behind the outer edge of the clavicular portion of the relaxed sterno-cleido-mastoid muscle firmly insert the thumb of the right hand, so as to compress the artery firmly against the first rib as it issues from between the scaleni muscles. Here too pressure is painful owing to the difficulty of avoiding partial compression of the brachial plexus, but the artery can be so completely compressed at this point that pulsation of the radial artery is arrested; less physical strength is requisite for this purpose than dexterity and sound anatomical knowledge of the situation of the vessel. The thumb of the compressing hand soon tires, however, and loses sensation owing to the strong pressure, and so various instruments have been devised to replace the fingers. One of the most convenient is a short stout key, the wards of which have been wrapped round with a pocket-handkerchief; then with the handle held firmly in the palm of your hand, you place the wards of the key on the artery and press it steadily against the first rib. The brachial artery owing to its position can be easily compressed. Place yourself on the outer side of the arm, clasp the upper arm with your right hand so that the second, third and fourth fingers are placed along the inner side of the belly of the biceps muscle about the middle of the arm or a little higher, then clasp the rest of the arm with the thumb and press firmly with the fingers against the humerus; the only difficulty here is to avoid compressing the median nerve, which at this spot nearly covers the brachial artery; by compressing the brachial artery we can easily stop the radial pulse, and we make use of this compression very advantageously, if, on account of a wound of the radial or ulnar artery, we wish to apply a ligature to one of them and at the moment have no bandage for enveloping and bandaging the arm according to Esmarch's method. In hæmorrhage from the arteries of the lower extremities we compress the femoral artery at the spot where it first commences to bear this name, that is just below

Poupart's ligament. We compress it here where it lies exactly in the centre between the spine of the pubes and the anterior inferior spine of the crest of the ilium, against the horizontal ramus of the pubes. The patient must be in a recumbent position; compression is made with the thumb and is easy, as the situation of the artery at this point is tolerably superficial. The femoral artery can be thoroughly compressed against the bone as far down as near the lower third of the femur, but it can only be done safely with the fingers in very thin individuals.

Although the more modern mode of compression, by simply tightly encircling the limb after previously induced local anæmia, has rendered the tourniquet unnecessary, we must not let it pass quite unnoticed. By a tourniquet we understand an apparatus by which we press an elongated, oval-shaped piece of wood or leather, a pelotte or pad, by means of a twisting, screw, or buckle and strap mechanism, firmly against an artery and the artery against the bone. As long-continued compression of the brachial or femoral artery is excessively fatiguing, we can employ it as an auxiliary with these arteries. The kind which we use at present is the screw-tourniquet of Jean Louis Petit. The pad, which slides along a band, is placed accurately on the spot corresponding to the artery, and immediately opposite the screwing apparatus, beneath which a few thin layers of linen are to be placed, to prevent too great pressure upon the skin. We then buckle the band firmly round the extremity, and by means of the screw we can now tighten the band and with it the pad till the artery below it ceases to pulsate. Should the orifice of an artery not be immediately discovered, in an amputation wound for instance, we may loosen the apparatus slightly by reversing the screw, so as to allow a little blood to flow from the artery, thus localizing its bleeding point; then retighten the screw of the tourniquet and apply the ligature to the artery. In this lies the great advantage of the screw. If the apparatus is well made and properly applied, it renders excellent service. The veins, and especially the subcutaneous veins, are certainly somewhat compressed by the band encircling the limb, but this is unavoidable; the pressure, however, by means of the pad, acts chiefly upon the artery. You can easily improvise a tourniquet with a broad band and a rounded piece of wood, or with a roller of bandage and a short stick; but if such an improvised compressorium does not firmly and effectually secure the artery, I would rather advise you to employ other and more certain

means of compression, of which we will speak directly. The convenience of checking serious hæmorrhage with the aid of the tourniquet may tempt you to leave it on for a lengthened period, till the hæmorrhage had perhaps ceased spontaneously and so save yourself the trouble of the ligature. This would be a great error. Within barely half an hour, if the tourniquet remains on, the extremity below it becomes dark blue, swells up, loses sensation, and the circulation of the blood in the part may be entirely arrested, thus causing its death; you would reproach yourself your whole life through for having made such a mistake, which might seriously endanger the life of your patient. *The application of the tourniquet is therefore only admissible as a provisional remedy for arresting hæmorrhage.*

To compress one of the larger arteries with the finger for a length of time till hæmorrhage ceases spontaneously, is difficult of accomplishment. Still, cases may arise where compression with the finger is the only certain means of stopping bleeding from some of the smaller arteries, as in hæmorrhage from the rectum or deep in the pharynx, when other remedies have left you in the lurch; here it is sometimes necessary to compress with the finger for half an hour or an hour, or even longer, as ligature of the internal iliac artery in the first instance, and of the carotid in the second, would be as dangerous as it would be uncertain for arresting the hæmorrhage permanently.

In order to avoid the danger which arises from damming up the venous blood by the constriction caused by the band encircling the limb, we can, before applying the tourniquet, tightly bandage the extremity from below upwards, so that the blood contained in it is forced out backwards. Formerly this was occasionally done with limbs which were just about to be amputated; the hæmorrhage was thus limited to an extremely small amount. A physician in Vicenza, Grandesso Silvestri, recommended an elastic bandage for enveloping the limb, and instead of the tourniquet the employment of thick india-rubber tubing, with which the extremity was to be several times encircled. Esmarch, without having any knowledge of this little known process of Silvestri, hit upon a similar method, and drew attention to the efficacy of it; and since that time it has very rightly been generally adopted. As a matter of fact we can perform operations of long duration, without any effusion of blood, on limbs that have been first bandaged in this manner and then con-

stricted, the bandage being removed, but the india-rubber tubing remaining; the extremities can be made perfectly bloodless and maintained so for about an hour, without the vitality of the part being endangered; after tying all visible vessels the elastic fillet is loosened and immediately the blood shoots back again into the vessels; if previously divided arteries have been overlooked and they now bleed, they must be at once seized and tied. *This method of making portions of the body quite bloodless and keeping them for a time in that condition is an immense advance in modern surgical practice;* operations have thereby become practicable, which were formerly not ventured upon.

Let us now pass on to those methods of compression which are intended for the permanent arrest of hæmorrhage. In modern times a new hæmostatic method has been recommended by Simpson, late of Edinburgh, the highly gifted surgeon and obstetric physician already known to you through his introduction of chloroform, a method, that I cannot certainly acknowledge as a perfect substitute for the ligature, but which is in many cases of practical value; it is the compression of the bleeding artery by a needle, *acupressure.*

Acupressure may be performed in various ways. In a stump after amputation, for instance, you introduce a long insect-needle, such as is also used for sewing, nearly perpendicularly, either from above or below, into the soft parts at a distance of a quarter to half an inch from the side of the artery, then turn the needle horizontally, and carrying its point just over or under the artery, you bring it out again almost perpendicularly on the other side of the artery and at a point equally distant from where it was first introduced, so that the arterial orifice is compressed by the needle against the soft parts, or better still against the skin or a bone; should this compression not be perfectly effectual, as would seldom be the case with the larger arteries, you must compress the artery against the needle by means of a loop of thread. In amputations I prefer making acupressure by torsion, acutorsion: I transfix the end of the artery after it has been drawn forward; and then with the needle make a quarter, half, or whole turn in the direction of the radius of the amputated surface, until the bleeding stops, and then insert the point of the needle deeply and firmly into the soft parts. These needles can be removed after forty-eight hours, without recurrence of the bleeding. It was only the more extended

experience of English surgeons as to the success of this bold proceeding that encouraged me to try it; from its simplicity it is very practicable, and dexterously performed, leaves nothing to be wished for. That acupressure will entirely supersede the ligature, as Simpson prophesied, I can at present hardly believe. In this hæmostatic operation, which I have resorted to in most of my amputation wounds for some years past, I use long gold needles with large heads, because silver is too soft, platinum too dear, and other metals rust too easily.

Quite recently small ligature rods have been used by Von Bruns, by which loops of silk thread are placed round the artery after it has been drawn forward, the loops are then drawn tight, and retained there; these rods with the threads are removed, as was the case with the acupressure needless, after forty-eight hours; I tried this recently on the femoral artery with complete success in an amputation of the thigh.

In venous hæmorrhages, or in hæmorrhage from a large number of small arteries, especially in the so-called parenchymatous hæmorrhage, bandaging *secundum artem* or the tampon must be employed with the aid of bandages, compresses and charpie. Tightly plugging or rather cramming the bleeding wound with charpie and a cord-like application of a bandage would be just as injurious for a permanency as a tightly applied tourniquet. Total anæmia, bloodlessness of an extremity may be continued without danger of its perishing, for an hour or an hour and a half, but not longer.

If you have hæmorrhage from an arm or leg, that you want to arrest by compression; if, for instance, large quantities of blood are being effused from a much dilated, diseased vein, or if the bleeding is from a number of very small arteries, you should bandage the extremity from below upwards after having previously covered the wound with a compress and charpie and placed several layers of folded linen (graduated compresses) lengthways on the extremity along the course of the principal artery. It is well, if to this application, which is called Theden's bandage, you add a splint, so that the extremity may be at perfect rest, for muscular contraction may easily set up bleeding again. These involutions, carefully applied, are chiefly used on the field of battle in gunshot and punctured wounds, and are of considerable efficacy; we can, by their aid, arrest hæmorrhage from the radial, ulnar, posterior and anterior tibial and even from the femoral and brachial arteries. This

bandage does not make the extremity totally bloodless, but only lessens materially the quantity of blood circulating in it. Bleeding from small or medium sized artéries can be permanently arrested by such a bandage, if it be left on for six or eight days. Also in hæmorrhage from the thorax, as on account of parenchymatous bleeding after removal of a diseased mammary gland, compression may be employed by laying compresses and charpie on the wound and keeping up a certain amount of pressure by applying bandages to cover the dressing firmly round the thorax. Such a bandage, however, if it is to be really effectual, annoys the patient extremely; it is on the whole always better to tie the bleeding arteries properly, even though there should be a great many of them; you, as well as your patient will be the better for it, as you will not be so easily annoyed and disturbed by the secondary hæmorrhage that is especially liable to occur after this operation in consequence of hasty bandaging and imperfect compression.

There are some parts of the body where compressive bandages are useless, as in hæmorrhage from the rectum, the vagina and from the depth of the nasal cavity. It is here that the tampon or plug finds its application.

There are many descriptions of tampons, especially for hæmorrhage from the vagina and rectum, the following is one of the simplest: you take a four-cornered piece of linen, about a foot square; by means of two or three or the five fingers of the right hand placed together in the centre of it, push it sufficiently high up into the vagina or rectum and fill the space left vacant by the withdrawal of your hand with as much charpie as you can get in, so that the vagina or rectum is fully distended internally and strong pressure is thereby exercised on its walls. Should the bleeding cease, you leave the plug till the next day or somewhat longer, according to circumstances, and then remove it by gentle traction on the linen which serves as a sack for the charpie. You can also make a large ball of charpie or linen tied together with thread, leaving a long string attached for the purpose of withdrawing the mass; but as a plug of this kind is at one time too small and at another too large, I prefer the first method, where the linen bag having been introduced can be filled to any extent that may be required. If the hæmorrhage comes from the *portio vaginalis uteri*, as sometimes happens after an operation on this part, it is certainly far safer to expose the *portio vaginalis* by holding back the posterior vaginal wall with a

large Sims' speculum and applying a tampon firmly and directly to the bleeding spot, for the mass of charpie which is necessary to fill the vagina of a woman who has borne several children, so that no more blood shall pass through or by the side of the plug, is incredibly large, and the pains which she suffers in consequence are very severe. In profuse hæmorrhage from the nose, which generally comes from the posterior part of the inferior meatus and certainly not uncommonly from the posteriorly situated cavernous tissue of the inferior turbinated bone, plugging the nose in front is entirely insufficient and useless; the bleeding continues and the blood either runs down into the pharynx or flows out of the other nostril, the patient in the meantime pressing the *velum palatinum* against the wall of the pharynx and so shutting off the upper part of the pharyngeal cavity. It would then be necessary to think of plugging the cavity of the nose from behind and this can easily be done by means of Belloc's sound. This exceedingly convenient instrument for the purpose consists of a tube or canula about five inches long, the end of which is slightly curved; in the canula is a steel spring stylet of much greater length, having a perforated button or knob at one end. You prepare beforehand a thick plug of charpie having a string or thread attached; this plug must be large enough to fill the posterior nares. To use this apparatus, you pass the sound, with the stylet drawn back, into the inferior meatus, push it quite to the back of the nares, and then press the stylet forwards, so that it makes its appearance in the mouth below the velum. You now fasten the string securely to the button or to the hole in it and then draw the canula and stylet back again out of the nose; the string tied to it as well as the attached plug must follow and when you make steady traction on the string the plug becomes tightly pressed into the posterior nasal orifice; if the bleeding now stops, as is usually the case if the plug (which must not be too long, otherwise the end of it might encroach upon the larynx) was not too small, you cut off the thread or string and leave the plug in the nose till the following day and then withdraw it from the nose by means of the string left attached; which is so much the more easy, as it is generally thickly covered with mucus and is consequently smooth and slippery. As this instrument is not always at hand, you can make shift with an elastic catheter or a thin piece of whalebone, or something of that kind, by passing it into and through the nose, seizing the end with the finger behind the *velum palatinum,* and drawing it into the

mouth in order to fasten the thread and plug to it. The use of such a substitute demands however more skill and dexterity than the use of Belloc's sound.

(3.) Styptics are remedies which act partly as astringents to the tissues and partly by causing remarkably rapid and firm coagulation of the blood. The number of remedies recommended is very large; but we shall only mention those which have furnished successful results under various circumstances.

Cold not only excites the walls of the arteries and veins to contract but makes the other soft parts contract also and thus compress the vessels; the current of blood gradually experiences greater obstacles and may even stagnate entirely should the part be completely frozen. The effect of cold as a hæmostatic remedy appears to me, however, to be very much exaggerated; I advise you, therefore, not to trust too much to it. Cold may be applied as follows:—in the first place we can inject ice water on the bleeding wound or into the vagina or rectum, into the bladder through a catheter, into the nose or into the mouth; the mechanical irritation of a forcible stream of water is added to that of the cold; or you may apply pieces of ice directly to the wound, or introduce them into cavities, or they may be swallowed, as in cases of hæmorrhage from the stomach or lungs; or finally you can fill a bladder with ice and apply it to the wound, where it may be kept on for hours or days.

The absolute rest, which must be observed in every case of hæmorrhage, as well as the diminution of the diameter of the arteries in consequence of the loss of blood that has already taken place may probably often have a greater influence in checking bleeding than the employment of ice, to which alone the good effect is attributed. I would not dissuade from the use of cold in cases of moderate parenchymatous hæmorrhage, but in bleeding from the larger arteries, you must not expect too much from it, and do not waste too much time over it, as in this case "time is blood—blood is life."

It is the same thing with regard to the local astringent remedies in general use, vinegar, alum solution, and such like, that also cause contraction of the tissues and so compress the vessels; they may be all very well for checking capillary bleeding from the nose, but you cannot expect any great results from their use.

The red-hot iron, ferrum candens, causticum actuale or the actual

cautery, acts by charring the ends of the vessels and the blood, and by the hard eschar thus formed the escape of blood is prevented. If you take a wooden-handled iron rod provided with a small knob at the one end, and having heated the knob to a white heat, hold it in the immediate neighbourhood merely of the bleeding part, a black eschar is at once formed; occasionally indeed the tissue flames up even from the radiated heat alone of the white-hot iron. A red-hot iron pressed on the bleeding spot has the same effect, but is apt to adhere to the resulting eschar and tear it off. These cautery irons are generally heated to the required temperature in a chafing dish by means of bellows. The actual cautery may under some circumstances be a very convenient hæmostatic; it was formerly the most celebrated styptic before the ligature was known. The Arabian surgeons used to make their amputating knives red-hot, a proceeding that even Fabricius Hildanus commended, although he preferred burning the orifices of the spirting arteries separately with a fine-pointed hot iron, in which he must have had an amount of dexterity that we may well envy.

In more recent times a method has been invented which must be noticed here: it is the use of platinum for operating, made red-hot by a galvanic battery. This was introduced into Germany by Middeldorpf; it is known as galvano-caustic, and in certain circumstances may be used with advantage; it only acts styptically, however, where the platinum is at a moderate red heat; at a white heat platinum wire can cut through the soft parts like a knife, but at the same time they bleed freely. You can understand that a cautery iron properly shaped for hæmostatic purposes as found in the surgical wards is not always at hand in actual practice; Dieffenbach, the most ingenious German operator of this century, as well as one of the most original of men, once arrested a severe hæmorrhage that set in after extirpation of a tumour on the back by means of the tongs, which he rapidly heated in the fire; he was alone at the time, in a miserable dwelling and had no other remedies at hand. A knitting-needle fixed in a piece of wood or in a cork and heated in the candle may in some circumstances be used as a cautery.

One remedy which may not only be put on an equality with the actual cautery in its effects, but occasionally surpasses it, is the Liquor Ferri Sesquichlor.; this forms with the blood such a firm, leathery, adherent coagulum that it is admirably suited for a styptic. To use it take a roll of lint or charpie, saturate it with

the Liquor Ferri, and having previously wiped off all blood with a sponge, press it firmly on the wound for the space of from two to five minutes: you will thus arrest tolerably severe arterial hæmorrhage. Should the first application prove ineffectual, try it a second or third time; this remedy will rarely fail you if you combine compression with it, but it makes an irritable corrosive slough, behind which decomposed pus mixed with gas-bubbles is not uncommonly formed; so that you should not employ this styptic without urgent necessity.

The application of German tinder and blotting-paper to bleeding wounds is an old popular remedy; German tinder becomes firmly adherent with the blood to the wound if the bleeding is but slight, but without simultaneous compression it is ineffectual in anything like severe hæmorrhage; occasionally it does good service and many surgeons esteem it highly. Dry charpie, firmly pressed on the wound, has, according to my experience, the same effect. I have a few times lately used the Penghawar Djambi, and can corroborate the statement that in large quantities and firmly pressed on the wound it acts really styptically, better than charpie; if it be as effectual as Liquor Ferri, I leave undecided, but it makes less of a mess about wounds, although remaining firmly adherent to them for several days. Penghawar Djambi is composed of the light-brown soft hairs from the trunk of Cibotium Cuminghii, a tree-fern indigenous to the East Indies.

Other styptic remedies are oil of turpentine and aqua Binelli, in which creosote is the principal effective ingredient; in the use of the former remedy only have I any personal experience and I can highly recommend it to you; when a student in Göttingen, it used to be particularly commended by one of our lecturers, Professor Baum, and I employed it once in a doubtful case with such striking success that I have a sort of veneration for it. It is in reality a very heroic remedy, not only because the application of oil of turpentine to a wound causes very severe pain, but also because it excites strong inflammation, not in the wound alone but in its vicinity as well. I will relate the case to you in which I used it. A young, weakly woman some months after her confinement suffered from extensive suppuration behind the right breast between the mammary gland and the fascia of the pectoral muscle; several incisions had already been made through the breast and by the side of it in order to give free exit to the large quantities of matter that were formed;

but the openings soon closed again, and the old ones had to be enlarged or new ones made, as healing did not take place in the suppurating cavity. After one of these incisions that I had carried down rather deeply, severe hæmorrhage set in, blood welled up continuously from the bottom of the abscess, without my being able to find the bleeding vessel; I first of all filled the cavity with charpie and bandaged over it; the blood soon came through the bandage. I removed it and injected ice-water into the different openings and the bleeding moderated; again I applied a firm compressive bandage and the bleeding seemed arrested; I had hardly got to my room in the hospital before I was hastily summoned by the nurse, because the blood was again soaking through the dressing I had applied; the patient had fainted, looked as pale as a corpse, and the pulse was very small. The dressing had to be immediately removed; I now introduced pieces of ice through the different openings into the cavity beneath the breast, but the bleeding did not cease. The patient passed from one fainting fit into another, the whole bed was full of blood and ice-water, the woman lay unconscious before me with cold extremities and dim glassy eyes, and the nurses were indefatigable in their efforts to resuscitate the patient now bleeding to death, by holding ammonia to her nose and rubbing her forehead with eau de Cologne; I, at the commencement of my surgical career, not yet inured by practice to coolness and presence of mind in scenes such as this of which I had been the originator—I shall never forget the situation! I was already thinking it would be inevitably necessary to quickly amputate the entire mammary gland, search for the bleeding vessel, and tie it, when I decided to make another attempt with turpentine. I soaked a few wads of charpie in the oil, pressed them in the cavity of the wound, and the hæmorrhage stopped immediately; the woman recovered rapidly; owing to the turpentine, which was removed after about twenty-four hours, very violent reaction was excited in the cavity of the abscess, the walls of which were thrown off; a subsequent active growth of granulations effected in three weeks a cure, which physician and patient had for months perseveringly but vainly endeavoured to obtain. How hæmorrhage is arrested by oil of turpentine and creosote solution I cannot tell you, as they do not produce particularly firm coagulation of the blood; probably owing to the intense irritation caused by them, a peculiarly energetic contraction of the divided orifices of the vessels ensues.

On the whole you will seldom see styptics used in the surgical wards; they are rather favourite remedies with physicians, to whom the application of the ligature and the transfixion of arteries is an unaccustomed affair. Where it is possible to tie and compress you should avoid styptics. In the face, neck, or perineum we may advantageously make use of the more efficacious styptics when there is parenchymatous hæmorrhage, if it makes no difference as to whether the wound suppurates or not; but if the hæmorrhage be excessive and if styptics have left you in the lurch, the subsequent application of the ligature is far more difficult, as wounds often get into a horrible mess from the styptics employed.

From the use of medicines recommended as internal styptics you have nothing to expect in surgical practice. Absolute rest, keeping cool, narcotics, laxatives in cases of congestive hæmorrhage, may now and then prove extremely serviceable as auxiliaries, but their action is too slow for the hæmorrhages with which we have to deal in surgery.

The general state of weakness resulting from profuse hæmorrhage is naturally most effectually combated by stopping the bleeding, but whilst thus occupied, those who are placed at your disposal to assist you may be employed in attempts to revive the patient during the repeated fainting-fits by means of smelling-salts, sprinkling with water, &c. Only when the hæmorrhage is arrested may you turn your attention to this point; you may then give strong wine, rum or cognac, hot coffee, warm soup, a few drops of spirits of æther or acetic æther, and at the same time ammonia and such like should be given to the patient to smell. Artificial warmth, which is very efficacious, should be quickly supplied by covering the bleeding patient with thick blankets that have been warmed before the fire. It is also very effective to envelope the extremities in elastic bandages in order to drive the blood contained in them into the interior of the body, as the extremities can dispense with blood for a longer time than the brain, the heart, or the lungs. Up to the present time it has never happened that a patient has bled to death in my hands, but I have met with several cases in which one, two, and five hours after large operations with considerable loss of blood the patients have been seized with dyspnœa and spasmodic convulsions, and have died, evidently in consequence of the great loss of blood; for such cases there is one extreme remedy, namely, to inject blood from a healthy person into the bloodless patient. This operation, which is called

transfusion, is tolerably ancient; it originated in the middle of the seventeenth century, and after people had for a time marvelled at the strangeness of the idea it was laid aside and derided, till, however, at the end of the last century it was again withdrawn from the darkness of oblivion by English physicians, and more especially by their obstetric physicians; after Dieffenbach had made some attempts, which he soon abandoned, to reintroduce transfusion into Germany, Martin, in recent times, has more especially the merit of having directed attention to this operation as a life-saving one, whilst Panum has treated the subject experimentally from a physiological point of view in a thoroughly fundamental manner. The instrumental apparatus consists of a knife, forceps, scissors, and a small narrow canula with a glass syringe to fit it, the latter to hold about 140—200 grammes (about 5—8 ounces) of fluid. You bleed a healthy strong young man from one of the veins of the arm in the ordinary manner to be hereafter described, and receive the blood, at first to the extent of about 140 grammes, in a rather deep vessel which should be placed in a wash-hand basin filled with water of the temperature of the body; the blood flowing into the vessel is kept whipped with a twirling-stick till the fibrine separates. While this is being done, the most distinctly perceptible subcutaneous vein at the bend of the patient's elbow is to be freely exposed by an incision through the skin; then two silk threads are passed beneath the vein, the lower one is drawn together without closing it entirely, so that no blood may escape from the subsequent fine oblique incision made by the scissors in the vein; the canula is pushed up into the now gaping opening of the vein, and the upper thread crossed over it without tying it in a knot; some blood must be allowed to escape through the canula so as to fill it and expel the air.

In the meantime the assistant has finished bleeding the healthy man and filtered the whipped (defibrinated) blood through a fine cloth; then the syringe having been first warmed is filled with the blood, inverted and the air entirely driven out. The syringe is now firmly fixed in the canula and the blood very slowly injected. Experience has taught that it is unadvisable to inject more than 140—280 grammes of blood, and that even this completely suffices to reawaken vitality. The syringe must never be entirely emptied and you must stop directly the patient shows any signs of dyspnœa. Having completed the injection you remove the threads and the canula, and treat the wound as in venesection. It has long been a

vexed question whether the blood to be injected should be deprived of its fibrine (defibrinated) or not. Panum's experiments have conclusively proved that fibrine is not necessary to the restoration of vitality in cases of "blood-starvation," i.e. transfusion, and that with the greatest care we may even cause injury by the introduction of coagula. The supply of blood-corpuscles as carriers of oxygen appears to be the essential restorative principle in this operation.

Possibly transfusion has still a great future in store; but it has become very doubtful if it will ever be of any value in those cases of extreme anæmia that arise from other and occasionally unknown causes; we draw these conclusions from the results of Panum's excellent experiments, according to which the blood itself does not nourish, but is only the principal channel and medium for distributing the nourishment. The experiments made by Neudörfer in the last Italian war on the wounded who had become anæmic in consequence of profuse suppuration have had no permanent results. Hueter has of late paid much attention to the subject of transfusion; he prefers and urgently recommends whipped and filtered venous blood to be injected into an artery (such as the radial or posterior tibial artery), in the peripheral (distal) direction, as was once formerly done by Von Graefe; as Hueter has clearly demonstrated that this arterial transfusion is performed almost more easily than venous, this method deserves the preference, chiefly because the danger of embolism in the pulmonary vessels is thus with certainty avoided; no abnormal symptoms made their appearance in the hand or foot of those operated on by Hueter either during or after transfusion; but I am very doubtful if in many cases we should succeed in introducing a canula into the above-named small arteries in a patient bleeding to death, we should then have to choose the brachial artery. The enormous rise in the temperature of the body, the appearance of bloody urine, cyanosis, dyspnœa, and other symptoms which arise after and occasionally even during the operation, plainly indicate that it makes a considerable inroad on the physiological activity of the organism. On the whole I am but little prepossessed in favour of this operation, which has always hitherto been unsuccessful with myself and my assistants, but must confess that it is extolled by many physicians as having very good results. More recently still direct transfusion with lamb's blood (the first and oldest form of this species of operation) has been again revived; fatal cases have

occurred during this operation as well as during direct and indirect transfusion with human blood.

The statements which have been made with regard to cases of successful transfusion of lamb's blood are not such as to cause me at present to alter my opinion as to this operation.

I cannot now discuss the treatment of the after-consequences of serious hæmorrhages; it will be evident to you that, as a general rule, the chronic effects, the defective formation of new blood, must be combated by dietetic and medical treatment of a strengthening and nourishing character.

LECTURE IV.

Gaping of the wound.—Union by plaster.—Suture.—Interrupted suture.—Twisted suture.—External changes perceptible in the united wound.—Removal of the sutures.—Healing by the first intention.

After the hæmorrhage from a wound has been completely arrested and the surface cleansed by washing it with cold water, you should satisfy yourself as to its depth and the character of the parts divided, and in doing this you must notice particularly whether a joint, or one of the cavities of the body, has been opened, large nerve trunks divided, or a bone exposed or injured. You will then turn your attention to the third symptom in a recent wound, that is, the gaping of the parts. Skin, fasciæ, and nerves will, when divided, separate; partly in consequence of their elasticity and partly because they are attached to muscles, which, being contractile, become shortened directly they are injured, and whose cut surfaces therefore, especially in transverse wounds, are more or less widely separated from each other.

We shall consider, in the first place, only those incised wounds where there has been no loss of substance, but merely a simple division of the soft parts. For such a wound to heal quickly, it is requisite that the two edges should be brought exactly together as they were before the injury, and to accomplish this we make use of strips of adhesive plaster or sutures.

In wounds where the cutis is scarcely divided, as in the small incised wounds of the fingers so often occurring in daily life, English sticking plaster is, as is well known, a good application. It consists of a solution of isinglass in water, mixed with a little rectified spirits of wine, painted over a piece of thin, but firm, silk or paper. The back is often painted over with tincture of benzoin, which communicates a pleasant odour to the plaster. As

the plaster readily becomes loose under moist applications, it is often advisable to paint it over when dry with a brush dipped in collodion.

Collodion is a solution of gun-cotton in a mixture of ether and alcohol. If this fluid be painted over the plaster and the adjoining portions of the skin, the ether very quickly evaporates, and a fine membrane, insoluble in water, remains behind, often puckering up the skin to a considerable degree. A further therapeutic use can also be made of this contractile action of the collodion by painting it on the inflamed skin either directly, or still better after previously covering the affected part with thin open cotton gauze, thereby producing moderate, equable pressure. In using collodion to fasten the plaster, take care not to apply it directly to the wound, for this will not only cause unnecessary pain, but may also induce inflammation and suppuration, which are just the things we wish to avoid.

If the cutis be divided and the plaster has to resist a more considerable amount of tension in order to keep the edges of the wound in apposition, the English plaster is insufficient, and we then use the proper *adhesive plaster*. Of this we have two kinds, in addition to numerous modifications, and attempts have also been made both to improve it and make it cheaper. The emplastrum adhæsivum, the emplastrum diachylon compositum, our common adhesive plaster, consists of olive oil, litharge, resin, and turpentine. When liquefied by heat it is spread on linen, and used generally in strips; these are laid over the wound, the edges of which are thus drawn together and kept in position. This plaster when freshly prepared adheres admirably, but it is apt to become loose if moist compresses are applied over it for some time. Very sensitive skins become irritated by it if often applied, and sometimes even after one application; and in such cases we may have recourse to other adhesive plasters, the emplastrum cerussæ (emplastrum adhæsivum album), which is prepared from olive oil, litharge, and white lead with hot water. This plaster adheres much less firmly, but it has the advantage of smearing the edges of the wound less than the yellow sticking plaster. A mixture of the two kinds of plasters in equal proportions lessens the objections, and combines the advantages of both.

As a general rule, for large wounds we now avoid the use of adhesive plaster more than formerly, and in its place employ the

suture more frequently. When we wish to unite wounds by the suture, we have, as a rule, the choice of two kinds—the interrupted suture (sutura nodosa) and the twisted suture (sutura circumvoluta). There is some truth in the objection that by the introduction of a foreign body, such as a thread or needle, we keep up a constant state of irritation in the edges of the wound, but this cannot counterbalance the great advantage obtained by the certainty with which the surfaces of the wound are adjusted by means of the suture. Hence, then, with the exception of adhesive plaster, almost all substitutes for the suture in which ancient and modern surgery has exhausted itself, after having been very much in vogue for a time, have been thrown aside. The suture has not yet been supplanted any more than the ligature, and probably never will be superseded.

There are certain portions of the body, such as the hairy scalp, the hands, and the feet, where we make a point of avoiding sutures, because any possible inflammatory processes which may occur, and which have often been attributed to the suture, are prone to assume a dangerous character; in my opinion, however, there is much prejudice at the bottom of this. Wounds of the head are especially prone to cause inflammation of the skin and subcutaneous cellular tissue; that this tendency is particularly increased by properly applied sutures, has not been proved statistically to any great extent. There are articles of faith of this kind handed down from teacher to pupil, from one handbook to another; many of them are a sort of Hippocratic tradition full of practical truth; these I willingly respect: others are based on undeterminate observations and prejudices founded thereupon, and among these latter I class the prohibition to apply sutures to wounds of the head. On looking back to my own experience, I remember more cases in which inflammation of the skin followed wounds of the head where no sutures were applied, than where they were. It is extremely important, however, in applying sutures to wounds of the head, to take care not to tighten them too much, to recognise at an early period inflammatory symptoms, and under such circumstances at once to remove the sutures. In applying sutures to flap-wounds we must provide for the escape of secretions by inserting drainage-tubes before we begin the dressing.

The necessity for applying sutures is determined by the amount of gaping and the form of the wound; they are required, for example, in flap wounds. We are never likely to take any unnecessary trouble in

introducing sutures unless urged by excess of surgical zeal, but sutures should be employed where, for the reasons above stated, sticking plaster is inappropriate or insufficient.

For the interrupted suture we use surgical needles and silk thread or wire. Surgical needles differ from ordinary sewing needles in having a lancet-shaped ground point which pierces the skin more readily than the round point of the sewing needle; besides this they are of somewhat softer steel than the English sewing needle, in consequence of which they do not spring so readily. They vary much in length and thickness, according as we wish to pass strong threads deeply where the edges are very tense, or only to use a fine thread to bring the edges into exact apposition. All needles, however, should have an eye of moderate size, so that time may not be lost unnecessarily in threading them. The needles may be either quite straight or curved in form. The curve should vary according to the localities where we wish to use the needles; for example, fine, very much curved needles are necessary for applying sutures to the parts about the inner canthus of the eye; large, much curved needles are used for sewing up a perinæum ruptured during labour, &c. The curve may be either in the whole needle, or only at the point: the variety is very great; for sewing up the wounds that are generally met with in practice you need only a few thin needles, and a few thick ones, some straight, others variously curved.

The thread is generally of silk, of varying strength and thickness corresponding to the needle. Formerly I always used soft red silk, which has long been employed for this purpose. In England, however, I met with a kind of undyed, strongly twisted silk, which, even when extremely fine, is so strong that wounds can be sewn up and their borders drawn together with thread as fine as a hair. This silk, moreover, imbibes so little moisture that it may remain for many days in the wound without swelling or irritating, and now I use only this so-called Chinese silk. Another material for sutures has lately been introduced from England and America, and that is, silver or iron wire. This must be exceedingly fine and soft. The iron wire must be very well annealed for this purpose. The use of this material was suggested by the long-known fact that pieces of metal, when allowed to remain in the body, often cause no suppuration, but the parts become healed up over them. It was thought, therefore, that the suppurations, which not seldom occur at the spots where the sutures have been introduced, might be avoided by

using metal, instead of the animal substance silk. It cannot, in fact, be denied that such suppuration at the points of suture is much less liable to occur with metallic than with silk thread, but the experimental investigations of Simon have shown that the suppuration about sutures is mainly dependent upon the thickness of the threads. I can from my own experience confirm the observation that very fine silk threads cause just as little suppuration in the track of the suture, and may become healed over just as well as metal ones. As a general rule I have not found catgut a very good material for sutures; the portion remaining in the wound sometimes becomes absorbed in three days, and the borders of the wound, unless by that time firmly adherent, are prone immediately to separate.

We now come to the *application of the interrupted suture.* This is done as follows:—With a toothed forceps you first seize one lip of the wound, introduce a needle through the skin at a distance of about two lines from the edge, passing it into the subcutaneous cellular tissue, and bringing the needle out again into the wound; now seize the other lip of the wound with the forceps, and pierce the skin from below upwards from the wound exactly opposite the first point of entrance, next draw the thread through, and cut it so that on both sides it is sufficiently long for a knot to be conveniently tied. Now make a simple knot, or, if the tension of the borders of the wound be great, a surgeon's one, draw it tight, and take care that the edges of the wound are in exact apposition, then make a second simple knot, and cut off both threads close to it, so as to prevent any long ends of thread getting into the wound.

If you wish to use wire, you thread the needle with it as with the silk, bend the short end which has been drawn through the eye of the needle, and pass the latter through the parts as above described. If the wire is very soft we can tie an excellent knot with it just as with a silk thread, but the whole of this manipulation is much less pleasant with wire than with silk, and on closing the knot the border of the skin is easily displaced, or the wire may get twisted, so that the suture holds less securely; this is very likely to happen with our German wire, which has not yet attained the softness of that made in England. The pleasantest metallic wires to use are those made of a mixture of gold and silver, and of platinum, of which marvellously fine, pliable, and at the same time firm wire

may be made. It would be, however, a ridiculous notion to wish to substitute these expensive articles for ordinary silk, with which millions of wounds have been excellently healed, and doubtless will be so in future. I pass over the many newly discovered appliances by which the wires can be fastened by knots or short twists; they show that those who enthusiastically advocate the use of the metallic suture have experienced many difficulties in fastening the knot. I first make a simple knot with the wire, then draw it together and make two or three quick, short, twists, and cut off both ends close to the twisted part. Where there is any tension of the borders of the wound, the finer the wire, the more apt it is to cut its way through, just as the silk does. I have seldom found the supposed objections to silk sutures sufficiently great to make me often take the opportunity of substituting metal ones. These latter I have occasionally preferred to use; of this I shall speak further when dealing with individual cases in the clinical wards.

The usual fault that beginners make is to draw the sutures too tight; they seldom apply them too loosely. In the former case, the borders of the wound, which almost always swell a little, become strangulated; this strangulation is certainly seldom so great as to cause the death of the tissues involved, but it sets up a condition of inflammatory excitement in these parts which soon shows itself in deep reddening and very early suppuration in the track of the suture; and unless we relieve this excitement by promptly cutting and removing the sutures the inflammation is very likely to spread, and the healing of the wound may be thereby very seriously interfered with.

Straight needles may be best introduced with the fingers. Curved needles, however, especially when small and when the wounds are deeply seated, can be introduced with more ease and security by means of particular kinds of needle-holders. Of these there is a great quantity, but of them all I am accustomed to use only the one invented by Dieffenbach. It consists of a forceps with short thick blades, between which the needle is firmly and securely held, and then passed through the skin in the direction of its curve. This perfectly simple instrument is sufficient for almost all cases, and in a skilled hand is surpassed by no instrument of the kind for security in holding and introducing the needle. Complicated instruments are suitable for unskilful surgeons, says Dieffenbach, in the admirable introduction to his 'Operative

Surgery;' the hand of the surgeon, and not the instrument, should operate. Practice and habit in the use of particular instruments cause one kind to be indispensable for one operator, and another for another. Thus, some find it inconvenient and troublesome to seize with the forceps the lips of the wound in order to approximate them, as I have just explained to you, though this method is far neater than holding them with the fingers; to me this latter would be extremely inconvenient; but it is quite allowable that every one should act according to his own manner and habit in the way which he finds most convenient. When I have to apply sutures at some depth, for example, in the velum palati, rectum, or vagina, I always use needles with handles.

The number of sutures to be applied depends naturally upon the length of the wound; as a general rule, sutures at a distance of one centimètre (·39 inch) apart are sufficient, but where very exact apposition of the edges of the wound and fine cicatrices are particularly important, as in wounds of the face, the sutures must be closer, and there should be strong ones deeply placed, at a distance from the edges of the wound, alternating with finer ones involving but a small portion of the edge (Simon's double suture).

The second kind of suture, the twisted, also called the harelip suture, is made by inserting a long pin with a lancet-shaped point through the borders of the wound; this is allowed to remain, and a thread of strong cotton or silk is passed round it, as I now show you. You take the thread with both hands, place it parallel to and immediately above the pin, transversely, therefore, to the wound: draw the thread downwards over the apertures of exit and entrance of the pin, so as to approximate the edges of the wound exactly (this is the so-called *Nulltour*); now you change the threads from hand to hand, and with the right thread in the left hand you pass round the left projecting end of the pin from above downwards, and you do just the same for the right end of the pin, with the left thread in the right hand; now you change the threads again, and make three or four similar so-called figure-of-8 turns; then make a double knot, and cut the ends of the thread close to the knot; lastly, with a small pair of cutting forceps made for the purpose, you cut off both ends of the pin as may be required, to prevent them from pressing on the skin, but they must not be made so short as to cause any difficulty in withdrawing them at a later period.

There is in addition a large number of other sutures, which for

the most part are only of historical interest, and which we here pass over; in our chapters on special surgery we shall have to mention a few peculiar kinds of sutures, adapted for wounds of particular parts, such as, for example, the intestines.

What now are the advantages of the twisted over the interrupted suture, and when do we employ it? These indications may be reduced to two factors, and the interrupted suture may be regarded as the simpler and more common. The twisted suture is employed, 1, when the tension of the lips of the wound is very considerable; 2, when the flaps of skin to be united are thin and unsupported, where the skin is very loose; in short, where the borders of the wound have a great tendency to inversion. The pins remaining in position give, in both cases, a more secure and firm support to the sutures, the pin acts in some measure as a subcutaneous splint for the edges of the skin; they are supported by it and are also held more firmly in position by the numerous threads on the outside. In many cases in which sutures have to be closely applied to the face, the interrupted and twisted kinds are used alternately; the latter serve to support the parts and resist tension, the former induce more accurate union of the borders of the wound already in position.

When the bleeding has been stopped, and the wound accurately brought together, all has been done that is at first necessary. Let us now notice what goes on in the closed wound.

Immediately after the edges of the wound have been brought together, they usually appear pale in consequence of the pressure exercised by the sutures upon the vessels of the skin; more rarely the borders of the skin are dark blue in colour; this always indicates great impediment to the return of blood through the veins, the cause of this being the loss of a portion of the blood-vessels. It is evident that the division of a large number of capillaries may very greatly disturb the communication between arteries and veins, so that at some point in the border of the wound the *vis à tergo* may be insufficient for the venous current; this dark blue colour of the borders of the wound most frequently occurs when the skin is very thin, or in cases where much of the panniculus adiposus has been removed, the veins of the skin emptying the greater part of their contents into the veins of this tissue. If this blue colour does not soon spontaneously disappear, a small portion of the edge of the

wound dies, a symptom to which we shall return when speaking of contused wounds, in which it is of frequent occurrence.

After a period varying from twenty-four to forty-eight hours, you find the borders of the wound often slightly swollen, and sometimes bright red; these symptoms are certainly often absent, especially where the epidermis is thick; but occasionally they spread, according to the extent and depth of the wound and also the tension of the skin, sometimes only two or three lines, and sometimes as many inches around the wound; within this area, the usual so-called local reaction takes place about the wound, which becomes slightly painful, especially on being touched. All this may be best seen in children and women with a delicate skin. About wounds of the face we often notice extensive œdema, especially of the eyelids; this often frightens beginners, but it is usually unattended with danger. In a not inconsiderable number of cases, if the sutures have not been applied too tightly, not only is there no immediate subsequent change in the borders of the wound, but they remain unaffected until healing has taken place; this is the most favorable and the ideal proper course, and one which is more and more frequently noticed with our improved methods of union and treatment.

The process which follows injury of the tissues, and by which also union of the flaps of a wound takes place, cannot be referred otherwise than to that category of mixed morphological and chemical changes of tissue which are comprehended under the designation of inflammation; and indeed, in such cases, we speak of a traumatic inflammation, that is, of an inflammation caused by an injury (τραῦμα). If, in twenty-four hours, these local symptoms have not extended so as to exceed the limits just indicated, you may at once consider that the process is running a normal course. It is a marked peculiarity of traumatic inflammation that it is strictly confined to the borders of the wound, and does not spread without special cause. From the third to the fifth day, any slight redness, swelling, pain, and increase of temperature which may possibly have been present in the injured part, will in great measure, if not entirely, have disappeared. If the symptoms increase on the second, third, and fourth days, or if some of them, such as severe pain and great swelling, become very marked at this time, after apparent subsidence, or if they remain with increasing intensity beyond the fifth or sixth day, these are all signs that the healing process is not pursuing the

wished-for normal course. This will be especially evident from the general condition of the patient. The whole organism is made to sympathize by the abnormal increase of the inflammation. At the end of this chapter, we shall refer to this general reaction, "the wound-fever." At present we shall confine our attention to the condition of the wounded part.

On the third day, often indeed on the second, you may carefully remove the pins of the twisted suture, supposing that you have also applied the interrupted kind. The best way to do this, is to seize the pin with Dieffenbach's forceps, which I have already brought to your notice; you then withdraw it with a gentle rotation, while you fix the twisted threads by laying your finger lightly upon them. The threads usually remain as a sort of clamp upon the wound, to which they are attached by some coagulated blood; they afterwards loosen spontaneously. By forcibly tearing away the threads you would unnecessarily strain the wound, and possibly tear apart the recently united edges. If at this time we carefully feel the edges of the wound, we shall find them, supposing that the œdema has already subsided, somewhat firmer than the healthy parts around; this state of firm infiltration disappears in a few days.

If you have applied many interrupted sutures, you may remove some of them that have little to hold, on the third day, others on the fourth and fifth days; only at those parts where the tension is very great, you may, as an exception, leave the threads for eight days or more, or even allow them to cut their way through the edges of the wound, if there is any real use in keeping together the borders of the wound which may perhaps be still gaping in some places. If, at an early period, the extension of the inflammation exceeds the normal amount, earlier removal of the sutures is necessary, lest the irritation should be increased: not unfrequently blood decomposing or mixed with pus is found at the bottom of the wound, and is the cause of the unusual symptoms of irritation; more of this by-and-by.

In removing the interrupted sutures, the following small precautions must be taken: cut the thread on one side of the knot, where you can most readily pass the thin blade of the scissors under it, without in any way stretching the wound; then seize the thread at the knot with a dissecting forceps, and draw it out towards the side where it was divided, so as not to separate the edges of the wound in taking out the thread.

Should you think, after removing the sutures, that the adhesion of the wound is still too weak to prevent the flaps from gaping, you may, by applying strips of English plaster, which you place transversely over the wound between the openings of the sutures, and fixing the ends (avoiding the wound) with collodion, give additional support for a few days; this will suffice to prevent any strain upon the edges of the wound, such as unavoidably occurs in injuries of the face, from the movements of the muscles in expression.

In from six to eight days the majority of simple incised wounds are sufficiently united to keep together without any further support; indeed, in many cases, this occurs between the second and fourth day. If, in the course of the following days, the blood which may have coagulated about the wound be carefully washed off, the young cicatrix appears as a fine red streak, as a scarcely visible fine line.

The process which we have just described is called *healing of wounds by the first intention.*

In the course of the next few months, the cicatrix loses its redness and hardness, and finally becomes perceptibly whiter than, and just as soft as the skin, so that for many years it continues to be recognised as a fine white line. It often disappears almost entirely after several years. Some of you who leave the university with many very visible cicatrices on the face, may comfort yourselves with the hope, that they will be scarcely visible in six or eight years, when the Philistine visage will become you less than it does a student. *Tempora mutantur nos et mutamur in illis!*

LECTURE V.

Inflammation.—The more minute processes in healing by the first intention.—Dilatation of the vessels in the neighbourhood of the wound.—Fluxion.—Different views regarding the causes of fluxion.

Gentlemen,—You are now acquainted with the changes visible to the naked eye, which take place in the wound while it is healing; let us now endeavour to examine the processes that develop themselves in the tissues from the time of injury until the formation of the cicatrix. For a long time attempts have been made to study and distinguish these processes more minutely; for this purpose wounds have been made on animals, and examined at different stages, but it is only the most exact microscopic examination of the tissue and direct observation of the changes after injury, that have enabled us to give a complete description of the healing process. I will endeavour to give you in a few words a distinct account of the results of these investigations, to which I have devoted much special study.

The interesting results, obtained in the manner above alluded to, have essentially contributed towards accustoming us to understand by "inflammation" mainly that succession of changes which may be perceived in the tissues on microscopical examination. We have recently become accustomed to regard these morphological processes as the absolute essence of the process of inflammation, and even to attach the term "inflammatory process" to the accession and typical subsidence of these histopoetic processes. I should not like to diminish your interest in these subjects at present, but the prevailing current opinions make it necessary for me to remind you beforehand, that—as in all organic growth, and in every change and process for the maintenance of the tissues of the body—the form which this takes, the smallest as well as the largest, is always the product of the chemical and physical forces inherent in the actual

material of the tissues; the inflammatory process is, like every physiological one that occurs in the body, of a chemico-physical nature; itself, we never see, even with the best microscopes; it is only the results of its action that are visible to us. These results, destruction and formation of tissue, have much that is peculiar, especially in their typical course, but their limits are as wide as life and death; the tissues may perish in an instant, or may be chronically diseased for years; of two new formations of exactly similar structure, one may have sprung up in a few days, the other may have required several months for its development; totally different causes may induce new formations of tissue having an extraordinary resemblance to each other. Were it not that I feared to confuse you, I would here enter more minutely into the difficulties which always present themselves whenever we treat of inflammation in general. Let me therefore now go at once into detail; later on we will return to the description of inflammation as a whole.

The changes which occur after injury of the different tissues are particularly manifest in the blood-vessels, in the injured tissue itself, and in its nerves. The influence of the nerves upon the inflammatory process, and of this latter upon the former, is unfortunately still surrounded by so much that is obscure that we shall not consider it. We must at once dismiss, as at present unanswerable, the question whether the finest nutrient (vaso-motor) nerves, which lose themselves in the various tissues (for the question at issue can only concern these) exercise any immediate influence over the processes which become developed in the injured tissues and in the vessels themselves; the more so because up to the present time there are but few parts of the body in which the ends of the nerves have been recognised with certainty, while for other parts we are quite in the dark, and we have no kind of knowledge as to the manner in which the nutrient nerves act, and just as little as to the relations of the ends of the nerves to the capillary vessels. In the lectures on physiology and general pathology your attention will have been already called to the imaginable possibilities and probabilities on this subject. If, therefore, in what follows, we say little about the nerves, it is because we know nothing of their action in this special process, not because we wish to deny their influence.

Let us take for an example the simplest tissue; let us suppose a vertical section through connective tissue, with a closed capillary

system near the surface of the skin, and magnified from 300 to 400 diams. Here you have a diagram of such a system.

Fig. 1.

Connective tissue with capillaries. A diagram. Magnified 350—400.

An incision is now made from above downwards into the tissue, the capillaries bleed; the bleeding soon stops, the wound is accurately united, no matter by what means. Now, what are the principal changes that take place here?

The blood coagulates in the capillaries to about as far as the next branching—to the next point of intersection of the capillary network. Some coagulated blood almost always remains between the edges of the wound (Fig. 2). Of the channels for the circulation in our diagram a few have become blocked up; the blood has to accommodate itself to this, and escape by the existing by-paths around the wound. It is obvious that it does this under greater arterial pressure than before. This pressure becomes greater, the greater the obstruction to the circulation, and the less numerous the by-paths (of the so-called collateral circulation). The result of this

increased pressure is the distension of the vessels, hence the redness in the neighbourhood of the wound and partly, also, the swelling.

FIG. 2.

An incision made. Closure of capillaries by blood-clot. Collateral distension. A diagram. Magnified 350 to 400 diameters.

This latter symptom has, however, another cause. The more the walls of the capillaries are distended the thinner they become; even under ordinary conditions of pressure, with normal thickness of their walls, they allow blood plasma to pass through to nourish the tissues, and now under increased pressure more plasma than usual will pass through the walls, saturating the injured tissue, and becoming absorbed by the latter by reason of its capacity for swelling.

You have here in a few words the explanation of the changes sometimes externally perceptible in the borders of the wound immediately after the injury; the redness and increased warmth due to the rapid development of the collateral circulation by reason of which a greater volume of blood circulates through the vessels near the surface; the swelling of the borders of the wound is caused by

the distension of the vessels and the swelling of the tissues, which again produce slight compression of the nerves, and thereby some amount of pain.

This, as it seems to me, exceedingly simple mechanical explanation would be of considerable value if it fully accounted for the entire subsequent course of the process, and could be applied to all inflammations which are not of a traumatic or mechanical origin. This, however, is not the case. Neither the great vascular distension that occasionally occurs some time after injuries, and manifests itself in diffused redness about the wound, nor the capillary dilatation which exists from the first in inflammations of spontaneous origin, can be referred to mechanical impediments of the circulation. If the disturbance of circulation, due to the incision, is only inconsiderable, readjustment speedily takes place; such so-called passive hyperæmias stop short of "inflammation." Their extension is very closely connected with mechanical conditions, whereas the redness in advancing inflammation often spreads beyond the immediate sphere of the mechanical impediment to the circulation; only when the capillary distension is connected with conditions of irritation of the tissue, and eventually induced thereby, are we accustomed to make use of the term "inflammation." There are various kinds of irritation which produce dilatation of the capillaries. Let us now take mechanical irritation. You see, for example, my ocular conjunctiva of a pure bluish-white colour, like that of every normal eye. Now I rub the eye freely, so that it weeps; look at it again, the conjunctiva becomes reddish, perhaps with the naked eye you may see distinctly some of the larger blood-vessels, with the lens you will see also the finer vessels filled with blood. After, at most five minutes, the redness has entirely disappeared. Look again into an eye where a small insect has accidentally got under the eyelids, as is constantly happening; the person rubs his eye, the eye weeps and becomes very red, the insect is removed, and in half an hour's time you will probably see nothing remarkable about the eye. If such irritants were to continue to work, acute inflammation would be the result.

We shall now only attend to the symptoms connected with the vessels; these originate suddenly, and as rapidly disappear, because the irritation has ceased; there was no mechanical impediment to the circulation. What is the immediate cause of these symptoms? Why do not the vessels contract instead of dilating? These

questions are as difficult to answer as the observation is easy to make, and to be repeated over and over again with the same results. The fact itself has been known as long as observations have been made; the old saying, "*Ubi stimulus ibi affluxus,*" refers to this. The increased flow of blood is the answer which the irritated vascular part gives to the stimulus.

Formerly, the process which induced this kind of redness was called *active hyperæmia* or *active congestion.* Virchow took up an older name, and brought again into use the term *fluxion* or congestion (*Fluxion, Wallung*).

You will now be in a position, assisted by your knowledge of general pathology, to recognise the fact that what is required here is to give a theoretic explanation of phenomena, which through all time have formed one of the most important objects of consideration in medicine. Astley Cooper, a very celebrated English surgeon, whose works you will read with pleasure in time to come, when you take up the study of monographs, a thoroughly practical surgeon, commences his lectures on surgery with the following words: "The subject of our present lecture is *irritation,* which, as it is the foundation of surgical science, you must most carefully investigate, and clearly understand, before you can expect to be masters of the principles of your profession, or to be able to practise it with credit to yourselves, or with advantage to those who may place themselves under your care."

This will show you what part the questions now under consideration, which may possibly appear to you as superfluous amusements of the mind and imagination, have played at various times; you will hereafter learn from the history of medicine that entire medical systems of the greatest importance, are based on hypotheses that were constructed for the explanation of these phenomena in the vessels, and of this irritability and excitability of the tissues in general.

This is not the place for an exhaustive account of the history of this subject, I will only remind you of a few hypotheses which have been lately advanced, with the already-existing knowledge of the vessels and parts visible by the aid of the microscope, with regard to the production of vascular dilatation from irritation.

You know from histology and physiology that arteries and veins, before they pass into capillaries, have muscular fibre cells, partly transverse and partly longitudinal, in their walls; that these fibres are more scanty in veins than in arteries, although there are very

great differences in this respect. Now, although it may be very difficult to make direct observations as to the effect of irritation on these minute arteries and veins, it is very easy to see its effects on the intestines, where we have essentially the same conditions, viz. a tube provided with longitudinal and transverse muscular fibres. But, irritate the intestine as you may, you will never cause dilatation at the spot where the stimulus is applied, but only a shortening or constriction, and consequent motion of the contents of the intestine, the rapidity of which will depend upon the frequency of the repetition of the contractions. But is it possible that dilatation of the capillaries should be induced by such increased rapidity of motion of the vessels and of the blood? Certainly not. In the 'General Pathology' of Lotze, the celebrated medical philosopher of Göttingen, you will find a few remarks that are so trenchant, and, like all the chapters on this subject, so excellently illustrate the brilliant genius and critical acumen of this author, that I shall make use of the imagery he employs. His remarks are: "Pathologists who seek to explain congestion by increased contraction of the arteries, assume the thankless task of the Danaides, they cannot produce the stopper which prevents the escape of the blood that is pumped in with so much difficulty. Overfulness results, if in the same space of time more is introduced and the same amount as before escapes, or if the same quantity is introduced and less escapes. If we now suppose a portion of a vessel to contract more actively and at shorter intervals, it will have as little influence in causing increased afflux or diminished efflux of blood as the stamping of a person in a stream would have in regulating the amount of water."

This sufficiently refuted hypothesis, that the dilatation of the capillaries resulted from a more rapid and energetic contraction of the arteries, was at least founded on known observations, but Lotze's own explanation, on the contrary, is so far from all analogy that we are unable to attach any value to it. Lotze's opinion is, that there is no objection to the assumption that the capillaries are affected differently from the arteries by irritation, that they may by nervous influence expand actively on irritation, by their molecules separating from each other. This opinion is a thoroughly arbitrary assumption, and to some extent opposed to recent observations. It is well known that with the microscope we can follow the circulation of the blood, both in the smaller arteries and veins, as well as in the capillaries in the web of the foot, in the mesentery, and in the tongue of the frog,

or in the wing of the bat; but the immediate effect of a slight chemical or mechanical irritant does not show itself immediately in the capillaries, but first in a contraction of the smallest arteries, sometimes also of the veins; generally this contraction passes off very rapidly, lasting scarcely a second, indeed it often escapes observation altogether, and we then assume that the duration and degree of the contraction are too slight to be measured by our observation. This brief contraction is then followed by the dilatation, the immediate cause of which is obscure even on microscopical observation. We shall soon see that we get no help from this explanation; but that the fluxion is the result of a kind of paralysis of the capillary walls, active as this symptom may appear. Even the most recent, extremely interesting observations of Golubew, who had the kindness to show me that the capillaries of the nictitating membrane of the frog contract transversely when exposed to strong electric shocks, do not appear to me, as far as I have considered the matter, to be at present perfectly applicable to the question of fluxion.

Virchow supposes that the excitement, the immediate cause of which may certainly be the contraction, is followed by rapid fatigue of the muscles of the vessels; after a tetanic contraction there is relaxation, just as in irritated nerves and muscles, a view which may find some support in a communication from Dubois-Reymond with regard to the painful tetanus of the muscles of the vessels of the head as a cause of headache on one side, a so-called hemicrania, since this supposed tetanus of the muscles of the vessels, dependent upon great excitement of the cervical portion of the sympathetic nerve, was certainly followed by their relaxation and great distension of the vessels, in short, by symptoms of cerebral congestion.

But in this view, which, it is true, explains the relaxation or temporary paralysis of the walls of the vessels following the contraction, and a consequent decrease of their resistance to the pressure of the blood, we must not forget, that it is by no means proved that the muscles of the vessels, once irritated and excited to rapid contraction, are indeed immediately paralysed, while this fatigue in other muscles usually occurs only after long repeated irritation. We should be obliged indeed arbitrarily to assume that the muscles of the vessels are particularly easily fatigued, but this is controverted by experiment. You know from physiology, that Claude Bernard has proved that the contractions and dilatations of the arteries of the head are under the influence of the cervical portion of the

sympathetic nerve, as I have already pointed out to you. If the upper cervical ganglion of this nerve be irritated, the arteries contract; if the nerve be divided, dilatation, (paralysis) of the arteries and capillaries is the result. These experiments may, as far as regards the irritation, be again and again repeated without producing fatigue of the muscles of the vessels, provided that the electrical current be not too strong; hence it may well follow, that we are unable to accept unconditionally the assumption of an immediate fatigue after a single irritation. Schiff, however, like Lotze, supposes that an active dilatation of the vessels is possible; he thinks that this necessarily follows from certain experiments; the mechanism of this, however, is to me utterly incomprehensible, for there are certainly no muscles that can actively dilate the vessels.

If the veins alone contracted strongly on being irritated, filling of the capillaries would doubtless occur as a consequence of the obstruction, and there would then be no difference between venous (passive) hyperæmia and fluxion. This assumption is, however, quite untenable; for it is quite inconceivable that the veins alone should contract on inflammatory excitement. That the veins do contract on mechanical irritation you may see, for example, in the femoral vein of a thigh which has just been amputated, to which Virchow draws particular attention, and this irritability of the walls of the veins certainly lasts longer than that of the nerves.

Henle some time ago advanced the view that the phenomena of dilatation of the vessels from irritation were directly caused by paralysis of their walls; Lotze, on the other hand, opposes this view and asserts that it cannot be supposed that the muscles should all be paralysed in a man in a violent state of irritation, in whom all the muscles are tense and the face glowing red, but this objection does not seem to me to be very tenable, and Lotze's other objection does not appear to me to hold good; he says, "how shall we account for the paleness, the contraction of the vessels that occurs in fright and terror? Does that look like violent muscular action if redness in anger and shame can be the effect of paralysis?" In my opinion, this proves nothing. In a terrified man, the muscles of the vessels may be thrown into a tetanic condition, which is usually rapidly followed by fatigue of the same muscles; immediately after a great fright we generally feel the blood pouring into our cheeks, directly we begin to breathe deeply, and recover from the shock; we soon become red and, at first, indeed, redder than is pleasant, and certainly

it not unfrequently happens that the pallor in many men from fright is often overlooked, and only the subsequent redness perceived. This explanation, moreover, may suffice for the paleness in terror, as well as for the phenomena of "shock," of which we shall speak when describing the effects of crushing injuries upon the body.

But apart from these objections, how can we imagine that the irritation of a nerve can produce an active, directly paralysing effect? Physiology, in fact, makes us acquainted with such phenomena as, for example, the obstruction of the heart's action from irritation of the pneumogastric nerve, of the movements of the intestines from irritation of the splanchnic nerve, &c. We assume here the existence of an inhibitory nervous system, which arrests the contractions of the muscles; could not there also be such an inhibitory nervous system for the vessels, *i. e.* nerves, the irritation of which suppresses the tone of the muscles of the vessels, and thereby renders the walls less capable of resisting the pressure of the blood? The whole theory of the inhibitory nerves is so exceedingly difficult to explain, that even a brief exposition of the probable possibilities of the process would lead us too far. I must therefore content myself with having called attention to the analogous physiological processes. Virchow and Henle agree in the view that the phenomena of fluxion depend upon paralysis of the vessels, although these learned men differ as to the origination of this paralysis. Generally speaking, the view is becoming more and more predominant that the muscles of the vessels, like those of the heart, are under the influence partly of sympathetic, partly of cerebro-spinal nerves, and that the former cause the rhythmical (automatic) contractions of the vessels, while the latter regulate and obstruct these contractions. Irritation of the sympathetic fibres would increase the contraction of the vessels. Their division would be followed by paralysis of the muscles of the vessels and vascular dilatation, but the latter phenomenon might also be caused by irritation of the inhibitory cerebro-spinal nerves.

The discovery by Aeby, Eberth, and Auerbach, that the blood capillaries are composed entirely of cells, might give rise to new hypotheses with regard to the irritability of the capillary cells, and their influence upon the dilatation and narrowing of the capillaries, although even this would not solve the mechanical difficulty which opposes the notion of an active vascular dilatation. In the action of local irritation, and perfectly local dilatation of the vessels, we may adopt one of two theories, either that the irritation disturbs directly

the function of the nerves of the vessels, or of the living cell-substance of the capillary walls, or that this disturbance is due to reflex action. The investigators who have in most recent times paid continuous attention to these subjects, allow that the protracted capillary dilatation in acute inflammation is dependent upon changes of the capillary walls, which may be the immediate effect of the inflammatory irritation. Cohnheim thinks that the inflammatory irritation alters the walls of the vessels in such a peculiar way that they not only become more yielding to the pressure of the blood, but also softer; to this, however, we shall refer later on. Samuel finds that inflammation essentially consists in alteration of the relations subsisting between the blood, the wall of the vessels and the tissues. It is not at present possible to give a more definite account of the chemical and physical modalities of these changes of the vascular walls which are only known to us by their consequences. This theory is so far an advance against Lotze's view, according to which the molecules of the capillary walls should separate from each other upon their nerve being irritated, as there does not appear, generally speaking, to be any nervous action in producing the capillary dilatations in the acute inflammation under our notice; this agrees also with the statements of Schiff, already alluded to, that the vascular dilatations which occur after division of the sympathetic are neither in themselves inflammation, nor do they, as a matter of course, induce inflammation.

You have now enough material to ponder over! No one of all the hypotheses which have been brought forward can lay claim to be a really complete explanation of the phenomenon of fluxion, though many of them may possibly contain the germ which may in time become perfectly developed. The recognition, however, of this truth, the separation of hypothesis from observation, is useful; it does not obstruct the ever progressive spirit of inquiry, but continually reinvigorates it! Congratulate yourselves, that it is permitted to you and the coming generation to follow up this subject until it becomes perfectly clear. We now leave this question, and in the next lecture shall study the effect of the wound upon the injured tissue itself.

LECTURE VI.

Changes in the tissue during healing by the first intention. Plastic infiltration. Inflammatory new formation. Development of the cicatrix. Anatomical indications of the process of inflammation. Conditions, under which healing by the first intention does not occur. Union of parts that have been completely separated.

THE dilatation of the capillaries and the exudation of the serum of the blood, usually accompanying it, which we have hitherto recognised as the proximate effect of the wound, cannot of course by themselves produce organic union between the two flaps of the wound which are brought into apposition; changes must take place on the surfaces of the wound, by which the latter become dissolved to some extent and blended into one; just as you make two ends of sealing-wax soft by heat, in order to fasten them together, so here the substance itself must become the connecting material if there is to be a perfectly firm and intimate union. This is, in truth, the final result of every healing process, both in the soft parts, and in the bones, although at times the course is somewhat circuitous.

Let us keep in mind the above diagram and suppose that only connective tissue with vessels has been injured, and that the question at issue is a reunion of this substance. Connective tissue consists, as you know, of cellular elements, and intercellular substance which generally appears fibrous. The cellular elements are partly the stable, *fixed*, long-known *connective tissue corpuscles*, that is, flat, nucleated, cellular bodies with long prolongations, which lie close to the connective tissue bundles, partly, the wandering cells discovered by Von Recklinghausen, which are identical in form, species, and vital peculiarities, with white blood cells and lymph cells, probably originate for the most part in the lymphatic glands, pass into the blood through the lymphatic vessels, occasionally

wander out of the capillaries and fine veins into the surrounding tissue, there to become fixed tissue cells, or again enter into the lymphatics (as observed by Hering) and blood-vessels, or undergo metamorphoses not yet discovered.

If the tissue of the flaps of the wound be examined some hours after the injury, it will be found quite full of wandering cells. These increase enormously from hour to hour, they infiltrate the fibrous tissue already softened by swelling, and even wander across from one flap of the wound to the other. While this is going on, the connective-tissue intercellular substance of the flaps of the wound gradually becomes converted into a homogeneous adhesive substance; with the increase and accumulation of the cells, the intercellular substance perishes, being probably consumed by these cells, so that a time soon comes when the surfaces of the wound in apposition consist almost entirely of cells, which are held together by a very small quantity of intermediate tissue, which subsequently becomes firmer, and at last fibrous. The adhesive substance, which is situated partly in the tissue and its interstices, partly between the flaps of the wound, this organic wound-cement (*Wundkitt*) which sometimes in twenty-four hours holds the flaps of the wound so firmly together that they can be torn asunder only with difficulty, is probably fibrine.

In the sketch below (Fig. 3) of the former diagram now further developed, you see in section the wound surfaces now united by newly formed tissue, which once for all we shall term *inflammatory new formation* or *primary cellular tissue*. Virchow calls it granulation tissue; Rindfleisch, germ tissue. The inflammatory new formation is preceded by a condition in which the still filamentary connective tissue is infiltrated with very numerous wandering cells, a state which may easily again become normal by reason of the atrophy of these cells, or by their wandering back into the vessels. This stage of cellular or plastic infiltration, in which the tissue is firmer to the touch than in serous infiltration, is always present, but in very varying degrees, and in very unequal distances at the edges of the wound, and it is often demonstrable only with the aid of the microscope. The development of inflammatory new formation from the plastic cellular infiltration can always be followed in every specimen of recent wound flaps by making microscopical examination from the normal tissue towards the wound.

The injury represents an inflammatory irritation, the effect of

which, as a rule, scarcely extends beyond the immediate vicinity of the irritated portion, and then very rapidly diminishes.

In the vast majority of cases there will be at least a slight layer of coagulated blood between the flaps of the wound; this extends also somewhat into the interstitial tissue of the flaps. Such a coagulum may interfere with the healing, as when from its extent, or other causes, it decomposes, or when it becomes converted into pus;

FIG. 3.

Diagram representing the surfaces of the wound united by inflammatory new formation. Plastic infiltration of tissue. New formation of vessels. Magnified 300—400.

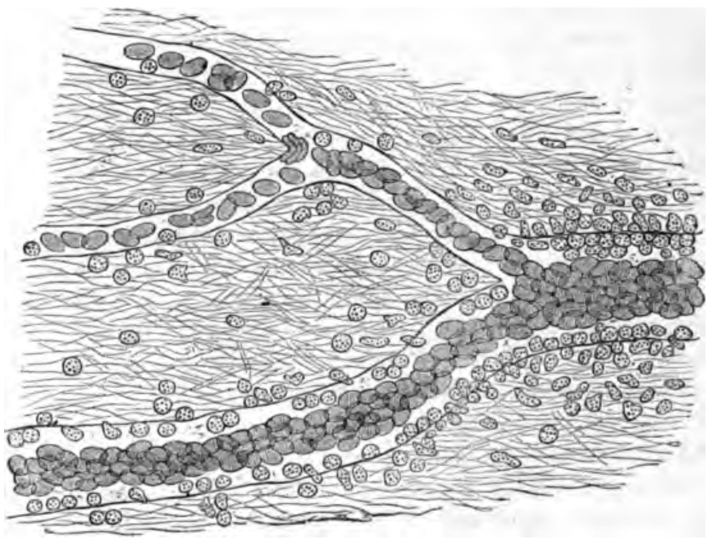
but it may without suppuration become cicatricial tissue and completely blend with the new formation in the flaps of the wound, or it becomes absorbed, having previously assisted in the mechanical adhesion of the wound. One of these two last events must occur for union by the first intention to take place. We shall hereafter describe how this comes to pass, and speak of the changes that the coagulated blood undergoes during this process.

We must now deal with the question, whence come the innumerable wandering cells that infiltrate all inflamed tissues immediately after their irritation, as they do here the tissue of the flaps of the wound? Very recently this question has been explained in the following remarkable manner, which ten years ago would have been at once considered as the fancies of a visionary. Cohnheim made the following extraordinary observation: he introduced finely pulverised aniline blue into the lymph-sac of the back of a frog, then irritated the cornea of the animal with caustic and found that a number of wandering cells (lymph-pus cells) containing aniline, gradually collected at the cauterised spot; hence the conclusion: at an irritated spot white blood-corpuscles wander from the vessels into the tissue; these white blood-corpuscles form the inflammatory cellular infiltration. After Stricker had first described how, in the nictitating membrane of the frog just removed, he had witnessed the passage of red blood cells through the capillary walls, Cohnheim made the further observation on the mesentery of the living frog, that the white blood-cells wander into the tissue through the walls of the vessels, and he remarked in addition that this occurred to a very great extent in the dilated capillaries and veins when the inflammation became increased by the drawing out and exposure of the mesentery. Although it afterwards appeared that an English observer, Aug. Waller, had already, many years previously, made similar observations on the mesentery of the toad and the tongue of the frog, yet the works of the German observers, Stricker, von Recklinghausen, and Cohnheim were quite independent of his, and to Cohnheim belongs the undivided honour of having correctly recognised the importance of his observations on the inflammatory processes, which he has constantly amplified up to the present time, and of having presented them in a way which will greatly affect and impress all modern pathology. (Fig. 4.)

It is difficult for you, gentlemen, to imagine what an extraordinary impression these recent observations, which I have put before you now as simple facts, produced upon all histologists, because you are not acquainted with the former point of view from which the origin of inflammatory new formations, and also that of complicated organised growths, was regarded. In accordance with earlier observations our ideas on this subject were somewhat as follows. It was assumed, that the cells of the connective tissue, of which only one kind, the fixed, was known, increased greatly by division as a

consequence of irritation, and that cellular infiltration thus resulted in acute inflammation. Place yourselves in imagination a few years back, at a time when nothing was known of the vital properties of young cells, of their amœboid and locomotor actions, and we were only taught to deduce the course of the pathological processes from various stages of the diseased, but perishing tissue, as still in the normal process of development; you will then readily understand that it was concluded without hesitation that the cells lying closely packed together in the inflamed tissue were formed out of

FIG. 4.



Vein and capillaries, from the mesentery of the frog, which had been exposed for several hours. Red blood-cells in circulation. Lateral position of white blood-cells which are seen wandering into the loose connective tissue of the mesentery. Magnified about 300 diameters.

each other. This was, even, a great advance, which was only possible after the overthrow of the theory of *equivocal generation;* for not long before, the opinion was firmly held that cells and tissue were produced from lymph-fluid, coagulated blood, and coagulated fibrine. The first observations on the divisions of cells in consequence of abnormal irritation, were made in England on cartilage by Redfern; these were followed by the observations of Virchow

and His upon the inflamed cornea. It was seen in both cases that, after cauterization with nitrate of silver, or after the introduction of a seton, the tissue was filled with young cells; in the original cells of the tissue, finger-biscuit shaped, then double nuclei, were seen, which were supposed to indicate a division; young cells were seen lying together in groups, whose origin from the tissue-cells appeared quite certain. Hence arose the idea that inflammation was a process in the tissues, which, directly independent of the vessels, was connected with a rapid luxuriant proliferation of the tissue-cells, with partial softening and disintegration of the intercellular tissue. Von Recklinghausen's discovery of the two kinds of cells to be found in connective tissue, as well as his discovery of the various movements of the pus-cells, might well raise the question, whether the proliferation of the cells in irritation of the tissue resulted from the fixed or movable connective-tissue corpuscles, but this matter was not discussed. Observations, however, were heaped upon observations, and we are now in the position to consider it in the highest degree probable, that all young cells, which, in the beginning of inflammation we find abnormally in the connective tissue, are wandering white blood-cells. This view is not assented to by all the observers who have lately paid attention to these questions; there is still a certain inclination in the minds of many to attribute to the stable cells of the connective tissue a share, as formerly supposed, in the acute process of suppuration. Von Recklinghausen expresses himself very reservedly on this point; Stricker adheres to the view, that the stable connective-tissue cells, and those of the cornea, become filled on irritation with new plasma, that they increase by subdivision, and assist in the formation of the pus-cells, without in any way denying the wandering of the white blood-cells. Cohnheim, Key, Eberth, and others, have expressed opinions contrary to the correctness of these observations, or rather, against the correctness of the interpretation of the phenomena observed by Stricker. The observations in question are so troublesome, so difficult, take up so much time, and are so confusing in their interpretation, that one cannot wonder that such apparently simple questions do not admit of a rapid solution.

It is evident that in view of the numerous fallacies to which the most distinguished investigators of this interesting subject are exposed, it is only with the greatest circumspection that any generally important propositions can be laid down. With regard to the

inflammatory changes in connective tissue, so far as my observations and critical investigations extend, I may venture to support the account given in the preceding paragraph. As far as regards cartilage, the views formerly adopted have at present undergone no change. Inasmuch as the hyaline substance of the cartilage possesses no canals through which cells can pass, we can scarcely do otherwise than assume that the increase of the cells in the cartilage cavities, occurring after irritation, is produced by division of the protoplasm of the cartilage cells, preparations of which I will lay before you hereafter. It is true that this hyaline cartilage has not been observed for successive days in a state of life and irritation, and therefore this observation is of somewhat inferior importance to those on living connective tissue. But there is no such acute suppuration-process in hyaline cartilage, nor any such purulent infiltration as occurs in connective tissue. With regard to the connective-tissue cells and those of the cornea, I must make this further assertion, that I consider a capacity for renovation and proliferation to be probable, except for those cells of these structures whose protoplasm is metamorphosed up to the nucleus in the tissue, consequently into the stable connective-tissue corpuscles and those of the cornea of such adult animals whose tissues may be compared with those of the human species. It has never been disputed, that the protoplasm, where it still exists as such in the cells, therefore in the still growing tissues of young individuals, may also as such increase and divide when acted on by certain irritants; possibly many differences in the views above alluded to may have their origin in the non-observation of these conditions. Similar conditions are apparent in the epithelial structures; yet it has never been asserted that the cells of the perfect epithelial tissues, the elements of the hair, of the nails, of the horny layer of the epidermis, the most superficial layer of scaly epithelium, can proliferate and be restored by irritation, whereas the continuous increase of the younger elements of these tissues is a physiological necessity for their growth, and cannot be denied. There is here only this difference, that the growth of these epithelial tissues goes on during the whole of life, whereas the growth of the connective substance only continues up to a certain period of life, and in this latter structure, after the subsidence of growth, no young tissue-elements, with the exception of the wandering cells, are to be discovered.

If there can no longer be any doubt, that by far the greater number of young cells which infiltrate the inflamed tissue, and which, under certain circumstances as we shall afterwards see, escape therefrom in the form of pus, are white blood-cells, or as we express it briefly, wandering cells, we have two questions before us, namely, why do so many cells wander into the inflamed tissue, and how do these often so enormous masses of wandering cells come into the blood, where do they originate? There are various opinions with regard to the escape of the wandering cells through the walls of the vessels. My own view is as follows: the first change that we see in living tissue in a state of inflammation is dilatation of the vessels, this is immediately followed by increased transudation and accumulation of white blood-cells in the peripheral layer of the calibre of the vessel. The wall of the vessel now gradually becomes softer, through a chemical process in every inflammation whose action is at present unknown, so that the white blood cells by reason of their active movements gradually push themselves into, and finally through, the walls of the vessels. Enlargement of the vessels, lateral position of the white blood cells, and softening of the vascular wall, appear therefore to me to be the necessary requirements for the extensive wandering of the cells. Recently, Cohnheim and Samuel have expressed similar opinions. Whence come the enormous quantity of white blood-cells, which escape in inflammation, is a question for physiology, and one which can only be answered by that science. Lymphatic glands and the spleen are the organs which first occur to us as possible sources, although it cannot be proved that with this enormous escape of cells there is also necessarily an extensive formation of lymphatic cells, yet this is extremely probable, and as we know from clinical experience that the lymphatic glands, in the neighbourhood of an inflammation, are almost always swollen, it is most natural to suppose that these are the source of the abnormally copious formation of wandering cells. In spite of the most zealous efforts, I have been unable to discover anything certain as to the morphological processes in this cell formation, although I consider it very probable that the lymph-cells originate by a process of budding in the meshes of the lymph-sinus of the glands.

To the above observations I must add one more remark, that during inflammation it not seldom happens that red blood-corpuscles also escape through the walls of the vessels; according to Cohnheim's experiments the increased intravascular pressure has a decided

influence over this process. According to Arnold, not only the red, but also the white blood-cells are especially prone to pass through the vascular walls, at those places where minute intervals (stigmata, stomata,) exist between the cells of the capillaries; during inflammation it is particularly the connecting substance of these cells of the capillaries which swells and becomes so yielding, that fine currents of blood-serum pass through it, and enter the lymphatic canals of the tissue.

Let us now return to our wound, and see what becomes of the tissue infiltrated with cells, of the inflammatory new formation, and how the cicatrix becomes developed therefrom. Whilst, at some distance from the wound, the cell infiltration extends slowly and sluggishly, the cells in the surfaces of the wound which are already loosely adherent, gradually assume a spindle shape, the inter-cellular tissue then becomes firmer, the spindle cells become converted into fixed connective-tissue cells, and the young cicatricial tissue at last assumes more and more the form of the normal fibrous, tendinous, connective tissue. It therefore appears, that the white blood-cells change into fixed connective-tissue cells, though this is still a point in debate, to which I shall subsequently return, for it is quite possible that this regeneration of the connective tissue takes a course of its own in a way at present unknown. Here again we have to encounter questions of various kinds. The newly formed, adhesive interlacing tissue very soon becomes firm, especially in healing by the first intention; even after twenty-four hours, we find, as already observed, its inter-cellular substance pretty firmly fibrinous, and the flaps of the wound are more or less infiltrated with this stiff substance; it is only the early stiffening of the inter-cellular connecting substance, formed of transuded serum, and softened connective tissue, that explains why the union is generally so firm, even on the third day, that the flaps of the wound hold together even without sutures, for without such connective substance, the young cellular tissue could not possibly possess such an amount of coherence. This stiffening connective substance is most probably fibrine, which consists of the transudation arising from the vessels under the influence of the extravasated blood-corpuscles, and possibly also of wandering cells. We have learnt from the excellent experiments of Alexander Schmidt, that most exudations contain the so-called fibrinogenous substance, which by union with the fibrino-plastic substance in the blood and other tissues forms fibrine, as we recognise it in the coagulated state.

Very definite proportions of fibrinogenous and fibrino-plastic substance are required to form fibrine; these favourable conditions occur in many inflammatory processes. Schmidt considers it probable that all firm fibrous tissue is produced and maintained by the fibrinogenous substance being precipitated from the blood in a certain manner round the cells, owing to these cells containing fibrino-plastic substance in a firm shape: for this, indeed, we must suppose certain specific actions of the cells, by which it would result that the product of coagulation would, in one place, assume the form of muscular fibres, in another, that of connective tissue. This view is very probable in the case before us, where it appears that fibrous connective tissue gradually forms out of the intercellular coagulated fibrine, although the correctness of this view is disputed. There is certainly no great quantity of fibrinous intercellular substance in the inflammatory new formation, but there is little doubt that the minute intervals between the cells are filled up by it. A little later, the young cicatricial tissue still appears to consist principally of spindle-cells very tightly pressed together, but then these spindle-cells diminish very greatly, especially by flattening; many, indeed, perish completely, and there now results a fibrous, thoroughly connective-tissue intercellular substance which is regarded partly as metamorphosed fibrine, partly as the metamorphosed protoplasm of the spindle-cells; the cicatricial tissue finally remains stable in this condition. Thiersch, who has recently again minutely investigated the healing of wounds, is of opinion, that the apparently fibrinous intermediate substance is not fibrine, but only metamorphosed connective tissue. I will not deny that there may be a really immediate adhesion, an instantaneous growing together of the softened flaps of the wound, although this would very seldom happen. Some time ago, I caused Dr. Gussenbauer to make a complete series of experiments upon healing by the first intention, with reference to these assertions of Thiersch. He has not been able to confirm the observations of Thiersch, but like Güterbock, who has also been paying attention to this subject, has obtained results which mainly agree with the above description, which is the produce of my own earlier studies.

What has become of the closed ends of the vessels, while these changes have been going on in the tissue? The coagulated blood in them is absorbed or organized; the vascular walls send out shoots, which communicate both with the vascular loops in the opposite

flap of the wound, and with each other. (Fig. 3.) In this way, however, only the union, at first but scanty, of the opposed vascular loops, is accomplished; these were already formed by the numerous meanderings and windings of the vessels which terminated in loops after the injury. This is not the place to enter into the details of these interesting formations of vascular loops; their development, however, is not due simply to dilatation, but also essentially to interstitial growth of the walls of the vessels. The original, previously existing vascular connections are thus replaced by a newly-formed vascular network which is at first far more copious.

Arnold has recently studied the process of vascular development in the most careful manner, and has seen the growth of the vessels, and the formation of vascular loops, proceed directly under his own observation in the tail of the tadpole. (Fig. 5.)

Although the heart and the first vessels of the embryo appear to originate in this way, that, of the collection of cells of the middle germinal layer, destined for that purpose, the peripheral ones go to form the walls of the vessels, the central become blood-cells, yet this method of formation of vessels and blood does not appear to occur in a later stage, at least the most recent observations of Rokitansky and others on this subject, as well as some earlier ones of my own, have not been generally accepted. According to Arnold's experiments, the only way in which the vessels are formed in the growing embryo, appears to be by the development of shoots from the sides of the vessels.

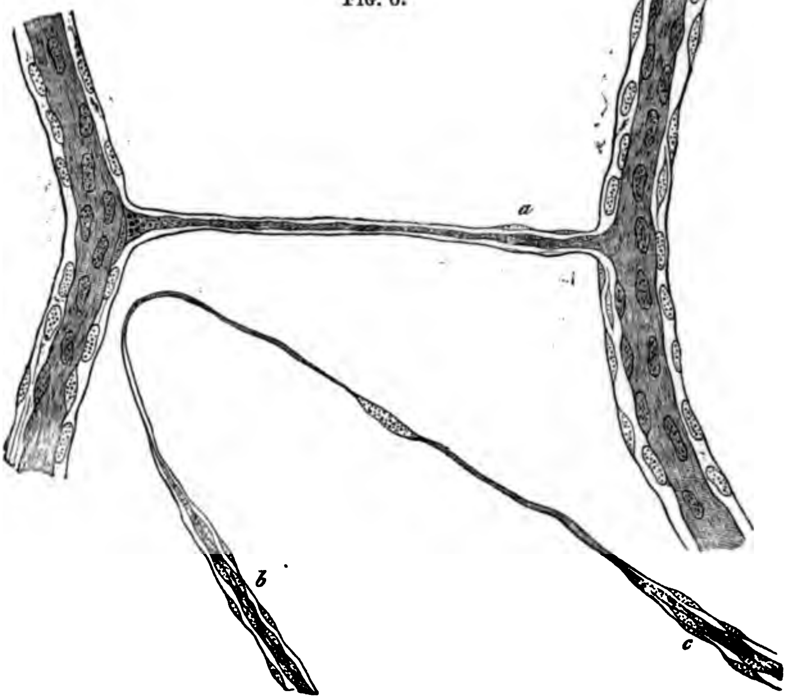
Formerly, with regard to the formation of the vessels of granulations and also of the vessels in many pathological new formations, I thought that it was necessary to assume another kind of vascular growth, namely, a formation of tubes by the apposition of spindle cells, as may be seen in *a*, *b*, *c*, in Fig. *6*; this I termed "secondary vascular formation" (as I have applied the term "primary" to the process which occurs in the formation of the heart and vessels in the middle germinal layer). The formation of shoots I have designated as "tertiary vascular development." However, after the more recent experiments, I willingly admit that the method termed by me "secondary vascular formation" has no probable existence, and that I may have failed to observe the fine strand of plasma (the shoot) and the fine tube, around which a deposit takes place of the spindle cells developed from the young adventitia. I must not, however, omit to mention that Thiersch's more recent experiments

FIG. 5.

Gradual formation of the vessels seen in *a*, *b*, and *c*. Ten hours are sufficient for these changes to take place. After Arnold. Magnified 300 diameters.

have led him to repeat his former statement which then seemed to me but slightly probable, that in the inflammatory new formation there existed a fine network of tubes connected with the blood vessels through the stigmata, this network being limited only by the cells of the tissue, and not by proper walls; this agrees completely with the more recent observations concerning the condition of the capillaries in inflamed tissues. According to this, there would certainly be blood vessels in this tissue, which are not circular canals, but irregular intercellular passages, possibly sometimes with only spindle cells for their boundaries.

FIG. 6.



Outlines of vessels from the vitreous body of the embryo of the calf. After Arnold. Magnified about 600 diameters.

As a consequence of the restoration of circulation through the young cicatrix, the disturbances of the process caused by the injury now completely subside; the redness and swelling of the borders of the wound disappear, and in consequence of the numerous vessels,

the cicatrix appears as a fine red stripe. The consolidation of the cicatrix must now take place; this is produced, on the one hand, by the partial disappearance of the newly formed vessels, whose walls fall together, and thus become fine solid strands of connective tissue, and, on the other, by the intercellular tissue becoming firmer and containing less water, the cells as above mentioned, either assume the flat form of connective-tissue corpuscles, or disappear; possibly some of them remain as wandering cells, and find their way back into the lymphatics or blood-vessels. To this condensation and atrophy of the cicatricial tissue its great contractile power is due, by means of which large broad cicatrices may sometimes be reduced to half their original size.

It might at the first glance appear to you contradictory that an apparently superfluously large capillary network should be formed in the young cicatrix, to undergo for the most part subsequent obliteration. We cannot explain this apparent excess, but there are pretty numerous analogies in embryonic development; the previous illustration (Fig. 6) will remind you that there is a period in the development of the fœtus in which even in the vitreous body a capillary network exists, which, as you know, disappears, leaving scarcely a trace behind it.

In order not to fatigue you with so-called theoretical subjects, I now leave this field for a short time, and before we conclude the subject of healing by first intention as a point fully understood, I shall make a few practical remarks on the causes which may prevent this mode of healing, even when the flaps of the wound are in apposition.

Healing by first intention does not take place:

1. When the flaps of the wound are brought together by plaster or sutures, but their tension, that is, their tendency to separate from each other is very great. Under these circumstances the plasters do not keep the wound perfectly closed, the sutures cut their way through the flaps of the wound, perhaps also the circulation in the capillaries is impeded by the great tension of the tissue, and thus the wandering of the cells and the development of the inflammatory new formation become disturbed. Only in the clinical wards can you form an idea as to the amount of the tension requisite for healing to go on, and as to the means which we possess for its relief.

2. A further impediment to healing is a large quantity of blood,

effused between the flaps of the wound; this acts, on the one hand, as a foreign body, and on the other, if it becomes decomposed, it checks the healing process by the influence of decomposition.

3. Other foreign bodies, for example, sand, dirt, alkaline urine, fæces, &c., also retard the healing, partly mechanically, partly chemically. These substances, therefore, must be carefully removed before union of the wound; in wounds of the urinary bladder from the abdominal walls, it is not usual to attempt to close the skin wound; the urine would force its way into the subcutaneous cellular tissue, there become decomposed, and set up terrible mischief.

4. Lastly, from a contusion, the effect of which on the flaps of the wound we may have failed to notice, there may have been an extensive disturbance of the circulation and extreme comminution of tissue, which has been followed by partial death of certain parts, or of the whole surface of the wound. Then, because there is no cell formation in the flaps of the wound, but only where the tissue is still living, we can understand that the small shreds of the destroyed tissue lie as dead foreign bodies between the flaps of the wound, and must prevent healing by first intention. If this mortification of the flaps of the wound, in which, moreover, there may be a temporary fibrinous adhesion, affects only very small particles, it is possible that these may rapidly undergo molecular disintegration, and become absorbed: this may often occur. When treating of contusions, we shall speak more in detail of this mortification of portions of the tissue, and their detachment from the healthy parts.

Practical experience in judging wounded surfaces, the result of many observations, will hereafter enable you in most cases to predict whether healing by first intention is to be expected or not, and you will thereby learn when it may be useful, even in doubtful cases to apply dressings to promote this union.

You will occasionally hear accounts of remarkable cases, in which parts of the body completely separated have again become united. The fact appears to be perfectly established; I have never had the opportunity of making observations on such cases; still in quite recent times very trustworthy men have reported that they have seen small portions of skin of the finger or nose, which have been removed by a blow or cut, again unite, after being carefully replaced and fastened on with plaster. Formerly on *à priori*

grounds, I contended against the possibility of such healing, but must now admit it for theoretical reasons, the movements of the cells permitting us to suppose that the detached portion, if not too great, may very soon become restored to life, by the entrance of wandering cells. The experiments of Thiersch also, have made it extremely probable that the formation of intercellular passages for the blood takes place in the flaps of the wound; through these passages blood may possibly circulate, though perhaps only slowly, through the portions which have been detached, even after twenty-four hours have elapsed. It is well known that we may successfully transplant a twig from one tree to another, but the circulation in plants is not by pumping, but the flow of sap takes place only by cellular force; the analogy, therefore, is rather a distant one. It was certainly more remarkable that a cock's spurs could be successfully transplanted into his comb; but between birds and men the difference in the formative process is very considerable, and every immediate transfer of observations is inadmissible in practice. When speaking of the cicatrisation of wounds with loss of substance, we shall describe more minutely Reverdin's discovery, that small portions of skin with epidermis can be inserted into granulating surfaces, where they will go on increasing. In his history of plastic operations Zeis has collected all the cases of union of completely separated portions of the body, which medical literature contains. Rosenberger has brought this account down to most recent times, and communicates a number of cases carefully observed by him, in which portions of the nose and fingers which had been chopped off, again united after having been carefully joined together. He confirms the earlier observations, that the epidermis, and sometimes also, slight superficial layers of the parts to be healed, generally become gangrenous, while the healing process goes on underneath.

LECTURE VII.

Changes visible to the naked eye in wounds with loss of substance. —Minute processes in healing by granulation and suppuration.—Pus.—Cicatrisation.—Views as to "inflammation."—Demonstration of preparations illustrative of the healing of wounds.

It now remains for us further to inquire what becomes of the wound, if, under the above circumstances, healing by the first intention does not take place. In that case we have an open wound before us, as the flaps gape, and the circumstances are the same as if the gaping wound had not been brought together, or as if a piece had been cut out, as in a wound with loss of substance. If we cover such wounds with some unirritating body, for example, a fold of linen dipped in oil, or with a thin sheet of gutta percha, and examine them daily (this is certainly seldom necessary during the first few days, and may be injurious), we shall find that the following changes occur. In from twenty-four to forty-eight hours, the borders of the wounds are sometimes slightly reddened, somewhat swollen, slightly sensitive to the touch, but they often exhibit no apparent change. Just as in healing by the first intention, these symptoms, even under these circumstances may be very slight, or entirely absent, as in old, relaxed, flabby skin, also in strong skin with thick epidermis. The above-mentioned slight symptoms of inflammation are best seen in the skin of healthy children; a very extensive, and daily increasing redness, swelling and pain of the parts about the wound denote an abnormal course. After the first twenty-four hours the surface of the wound has undergone but little change. All over it you still recognise the tissues pretty distinctly, although they have assumed a peculiar, gelatinous, greyish appearance (from the adherent fibrinous

material); besides this, there are yellowish or greyish-red minute particles on the surface of the wound; these, on closer examination, will be found to be small, dead fragments of tissue, enclosed in gelatinous fibrine, but still firmly adherent. On the second day, more or less thin, reddish-yellow fluid is seen upon the wound, the tissues appear more uniformly greyish-red and gelatinous, and their boundaries begin to appear indistinct. The third day, the secretion from the wound is pure yellow and somewhat thicker, most of the yellowish, dead particles of tissue escape with the secretion, they become dissolved, and pass off with a portion of the fibrine in the form of small, yellowish, soft granules, and clots; the surface of the wound becomes more even and uniformly red, *it becomes clean*, as we say technically. If you had not bound up the wound (a stump after amputation, for instance), and had received in a vessel the secretion that escaped, this latter would be found on the first and second day to be bloody, brownish-red, then gelatinous, dirty, greyish-brown, then dirty yellow; at the points where the secretion escapes from the wound, fibrine not unfrequently stiffens in drops. If you carefully examine open wounds, or use a lens for this purpose, you will see even on the third day, numerous red granules, scarcely as large as a millet-seed, projecting from the tissue, *small granules, granulations, fleshy warts*. By the fourth or sixth day these have already become much more developed, and they gradually coalesce into a finely-granular, bright-red surface, the *granulating surface;* at the same time, the fluid escaping from this surface becomes thicker, of a pure yellowish creamy consistence; this fluid is *pus*, and when of the quality here described, it is good pus, *pus bonum et laudabile* of the old authors.

There are very many varieties of this normal course; these chiefly depend upon the nature of the parts injured, and the kind of injury; if large shreds of tissue on the surface of the wound die, the wound takes much longer to clean, and you may then sometimes perceive for several days the white, adherent, dead fragments of tissue upon the surface of the wound, most of which is already granulating. Tendons and fasciæ are particularly prone to have their circulation so impaired even by simple incised wounds, that they die to an unexpectedly great extent from the cut surfaces, while there is but little death of the looser cellular tissue and of the muscles. The reason for this undoubtedly is, on the one hand, the

deficient vascularity of the tendinous parts, and on the other, their firmness, which is an obstacle to any rapid softening and blending process at the border of the living tissues. The same thing occurs in bones, especially in the cortical substance of long bones, where it often enough happens that a layer of the injured bone perishes, and sometimes requires some weeks for its detachment. Other obstacles to active development of granulations are to be found in general constitutional states of the body; you will see, for example, in very old, or very debilitated persons, or badly nourished children, that granulations would not only be developed very slowly, but also that, when formed, they will look very pale and flabby. Later on, at the close of this chapter, I will give you a short review of those anomalies of granulation which occur in daily experience in large wounds, and are to a certain extent normal, or at least customary.

If we now return to the description that has been given of the normally developing granulation surface, you will notice subsequently as the secretion of pus goes on, that the granulations become more and more elevated, and, sooner or later reach the level of the surface of the skin, and not unfrequently rise above it. With this process of growth, the individual granules become thicker and more confluent, so that they can scarcely be recognised as separate nodules, but the whole surface now assumes a glassy, gelatinous appearance. The granulations sometimes remain for a long time in this condition; we have then to use various remedies to restrain the proliferating new formation within certain limits requisite for healing; particularly at the periphery, the granulations ought not to project above the level of the skin; for it is there that the process of cicatrisation has to commence. You will now see the following metamorphoses gradually taking place: the entire surface contracts more and more and becomes smaller; on the border between skin and granulations, the secretion of pus diminishes; first a dry red border, about one millimètre broad, forms and advances towards the centre of the wound, and the more this advances and covers the granulating surface, it is followed by a pale bluish-white border which passes into normal epidermis. These two seams result from the development of epidermis, which advances from the periphery towards the centre; cicatrisation takes place, the young border of the cicatrix advances perhaps one or two millimètres daily until it finally covers the whole of the granulating surface. The young cicatrix then looks pretty red, and is thus

sharply defined from the healthy skin; it is firm to the touch, more so than the cutis, and is still very intimately connected with the subjacent parts. As time goes on, after some months, it gradually becomes paler, softer, more movable, and finally white; it goes on diminishing in the course of months and years, but often remains whiter than the cutis during the whole of life. In consequence of the strong contraction which goes on in the cicatrix towards the centre, the neighbouring portions of skin are often very much drawn together, an effect which is sometimes very welcome, but sometimes very much the reverse, as when, for example, such a cicatrix on the cheek draws down the lower eyelid, and causes ectropion. You can easily understand that a wound and a cicatrix can only contract in all directions when the subjacent parts, as well as the borders, permit elongation; wounds of bones, and wounds with stiff immovable borders cannot diminish in size by contraction, but only by cicatrisation, and therefore require much longer time for their cure.

You will occasionally see it asserted, that the cicatrisation of the granulating surfaces may sometimes proceed from isolated patches of epidermis becoming developed among the granulations. This only holds good of cases where a portion of cutis with rete Malpighii has remained in the midst of the wound, as may easily happen, for example, in gangrenous wounds, as the caustic agent may penetrate to very unequal depths. Under such circumstances, epidermis immediately forms from a small portion of remaining papillary layer of the skin, that has any, even the thinnest possible covering of cells of the rete Malpighii; at these spots there are then the same conditions as when a blister has been raised on the skin by cantharides plaster, by which the horny portion of the mucous layer of the cutis is raised by the very rapidly occurring exudation; no granulations are afterwards formed if you do not continue to irritate the surface, but horny epidermal scales immediately develope from the mucous layer. If, however, there be no such remnant of rete Malpighii, we never have these island-like patches of cicatrix, but the formation of epidermis only takes place gradually from the periphery of the wound towards the centre. I am so certain about this, that I think surgeons who assert that they have seen anything different are in some way mistaken. The results of transplantation of portions of the skin with epidermis, as practised by Reverdin, appear to me at any rate, to be very much

in favour of the view that epithelial development takes place only from epithelium.

Now that we have considered the external conditions of the wound, the development of the granulations, of the pus, and of the cicatrix, we must turn our attention to the more minute changes by which these external appearances are induced.

Our best plan will be again to represent a relatively simple capillary network in the connective tissue, and to join thereto what we are now considering (Fig. 1, p. 69). Imagine a crescentic piece to be cut out of it from above; there will first be bleeding from the vessels, which will be arrested by the formation of clots as far as the next branches. There will then be dilatation of the vessels in the neighbourhood of the wound, though only of brief duration; this is due partly to increased pressure, partly to fluxion; an increased transudation of blood serum, consequently an exudation is also here a necessary consequence of the capillary dilatation from the causes above given; the transuded serum also contains some fibrinogenous substance, which, possibly by the influence of the newly formed cells, coagulates to fibrine in the most superficial layers of the tissue, while the serum escapes, mixed with blood plasma. The vascular network would now assume the form shown in Fig. 7, p. 99.

It must generally be the case that at the surface of the wound more or fewer particles of the tissue will die, inasmuch as the vascular obstruction must, of course, seriously interfere with the nutrition of tissues but poorly supplied with vessels, and especially where the tissues are stiff the dilatation of the vessels will be impeded; this superficial necrosis is certainly scarcely visible to the naked eye. Let us assume that the upper layer of the wound, shaded in the diagram, perishes in consequence of the changes in the conditions of its circulation. What will now take place in the tissue itself? Essentially the same changes as in the united flaps of the wound; wandering of white blood-cells through the walls of the vessels, the collection of masses of these cells in the tissue with the effects previously described, plastic infiltration, and inflammatory new formation. But, inasmuch as there is here no opposing wound surface with which the new tissue can blend, to be then quickly transformed into connective tissue, the cells which have escaped from the vessels at first remain on the surface of the wound; the exuded fibrinous material on the surface of the wound becomes

soft and gelatinous, at the same time, the cellular infiltrated tissue of the surface of the wound assumes the same peculiarities; the soft connective substance in which the young vessels shortly grow, even if only present in small quantities, holds together the cells of the inflammatory new formation, whose number is constantly increasing. The granulation tissue is thus formed. Granulation tissue is therefore a highly vascular, inflammatory, new formation, a

FIG. 7.

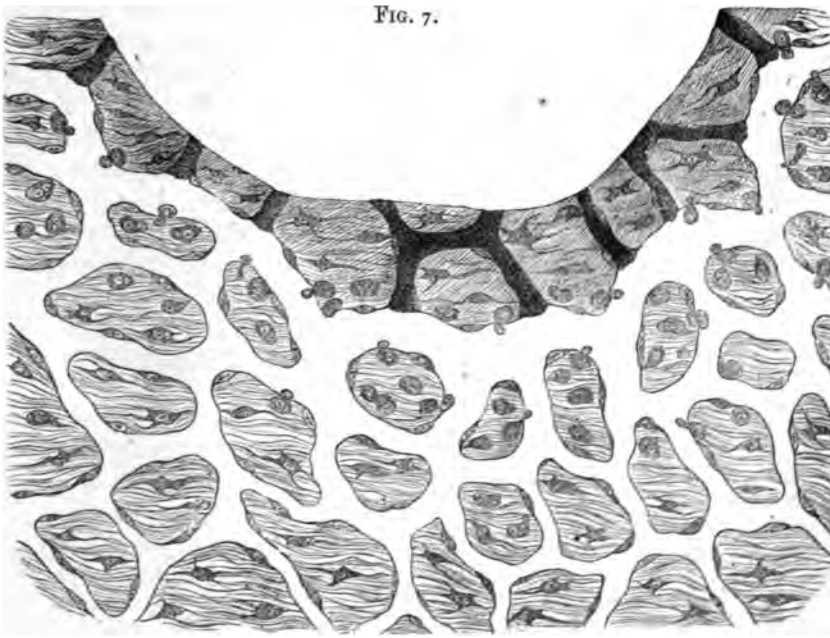
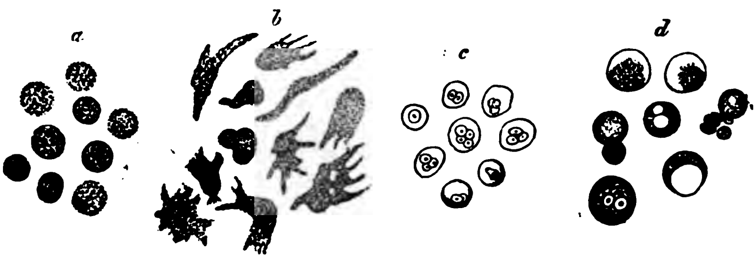


Diagram of a wound with loss of substance. Dilatation of the vessels. Magnified 300—400.

new formation caused by inflammatory disturbance of nutrition. At first its growth is constant, and is in the direction from the base of the wound towards the surface; the tissue is, however, of different consistence in the various layers; its superficial layer particularly is soft, and, in the uppermost strata, of fluid consistence, for here the intercellular substance is not only gelatinous but fluid, this uppermost thin fluid layer, which is continually escaping and being constantly renewed from the granulation tissue by wandering of the cells, is the pus (see Fig. 8).

The pus therefore, in this case, has its origin in the granulation tissue, and consists of young cells which have wandered from the granulation vessels and also from the granulation tissue. We say "the wound secretes the pus." If we collect pus in a vessel, and let it remain quiet, it separates into an upper, thin, clear layer, and a lower, yellow one; the former is fluid intercellular substance, the latter contains chiefly pus-corpuscles. These on microscopical examination are found to be round, finely punctated cells, of the size of white blood-corpuscles, with which they are, in fact, identical. But it is to be observed that these cells, as long as they are in the lymph and blood, exhibit, as a rule, only one large nucleus, but after they have escaped from the vessels they become so changed as to contain three to four small dark nuclei, which become particularly distinct on the addition of acetic acid, because it dissolves the pale granules of the protoplasm, or at least swells them so that the cell substance becomes transparent. This is the only morphological difference which is pretty constantly to be found between white blood-cells (which again are identical with lymph-cells) and pus-cells. The nuclei are not soluble in acetic acid. The entire globule is readily dissolved in alkalies.

FIG. 8.



Pus-cells from fresh pus. Magnified 400 diams. *a*. Dead without addition. *b*. Various forms that the living pus-cells assume in their amœboid movements. *c*. Pus-cells after the addition of acetic acid. *d*. Pus-cells after the addition of water.

At *a* we see pus-cells, as they usually appear, when we cover a drop of pus with a thin glass, and examine it under the microscope without any addition. The already mentioned observations of von Recklinghausen have shown that only the dead cells have this rounded form; if we observe the pus-cells in the moist chamber

on a warmed object table (according to M. Schultze) we get a most beautiful view of the amœboid movements of these cells. These movements, which go on only slowly and sluggishly at the temperature of the blood, and by means of which the cells assume the most extraordinary forms (*b*), become much more rapid at a higher temperature, and, again, more sluggish at a lower one. The number of pus-cells in pus is so great, that in a drop of pure pus under the microscope the fluid intercellular substance is quite imperceptible. Chemical examination of pus is difficult, in the first place, because the corpuscles cannot be completely separated from the fluid, also because the pus obtainable in large quantities for chemical examination has usually been in the body for a long time, and may have changed morphologically and chemically; and lastly, because protein substances chiefly are contained in pus, and it has not hitherto been quite possible to effect their separation. If we let pus from a wound stand in a glass, the clear, bright, yellow serum becomes sometimes more, sometimes less, in quantity than the thick straw-coloured sediment which contains the pus-corpuscles. Pus contains from 10 to 16 per cent. of fixed constituents, chiefly chloride of sodium; the ashy constituents are much the same as those of blood serum. Recent examinations of pus have shown that myosin, paraglobulin, protagon, besides fatty acids, leucin, tyrosin, are constant constituents. In pus collected in the body, acid fermentation does not readily occur; pure fresh pus having an alkaline reaction becomes, however, sour if it is left standing for some time (several weeks) even in a covered glass, and protected from drying up by evaporation.

Let us now return to the granulation tissue, where we have still an important part to consider, namely, the numerous vessels to which its red appearance is due. The extensive vascular loops that must form on the surface of the wound, and which in the diagram (Fig. 9, page 102) are much too fine and too few, commence, with the growth of the surrounding granulation tissue, to become more elongated and more and more tortuous; toward the fourth or fifth day new vessels develope, as in healing by the first intention, in the form of fine, lateral, capillary communications, which may commence here partly as plasma shoots, partly as intercellular passages, and the tissue is soo[illegible] excessive number of vessels; these have such [illegible] rance and thickness of the entire gr[illegible] recognisable in the dead

body, where the fulness of the vessels is absent, or at least, much less marked than during life, and consequently the entire tissue appears pale, relaxed, and much less thick. The question arises, whence come these remarkable, small, gradually confluent, red nodules, which are visible to the naked eye? Why does not the surface look even? This, indeed, is frequently enough the case; the granules are by no means equally clearly defined; the explanation

FIG. 9.

A diagram of a granulating wound. Magnified 300—400.

of the cause of their shape is, however, not so simple and easy. It is generally assumed that the granules are to be considered as an imitation of the papillæ of the cutis, but apart from the fact that it is unintelligible why such structures should be imitated in muscle and bone and that the granules are usually ten times as large as the cutaneous papillæ, this is no real explanation. The appearance of

the granules doubtless depends upon the arrangement of the vascular loops into distinct tufts and knots, and upon certain boundaries between these separate groups of vessels. We might therefore assume that the vascular loops acquire this form without known cause. But it seems to me natural to compare them to the circumscribed capillary districts already formed in the normal tissues, and which are very numerous, especially in the skin and adipose tissue. You know that every sweat and sebaceous gland, every hair follicle, every fat lobule, has its own, almost closed, capillary network, and by the enlargement of this latter, the peculiar, closed, vascular forms of the granules might arise. In fact, in the cutis and in adipose tissue, you will see the individual fleshy growths particularly sharply and clearly defined, whereas this is less often the case in muscle, where such limited capillary districts do not occur. Whether this explanation is correct, can only be decided by artificial injection of freshly formed granulations, which are still connected with the base from which they have sprung. Till then, my explanation must be regarded as only an attempt to refer this pathological new formation to normal anatomical conditions.

The above sketch (Fig. 9), in which, on account of the great enlargement and small vascular districts which have been depicted, we can only recognise the commencement of the granulations in the small groups of the vascular loops, may serve you as a diagram of the development of the granulation tissue, with the distribution of its vessels, and of its relations to pus and to the subjacent matrix, as it has developed from Fig. 7.

If the advancing growth of the granulations were not arrested at some limit, a constantly growing granulation tumour would be the necessary result. Fortunately this never, or at least extremely rarely occurs. You know already from the description of the external conditions, that the granulations as soon as they have reached the level of the skin, sometimes even earlier, cease to grow, become covered with epidermis, and retrograde to a cicatrix. The following changes then take place in the tissue.

In the first place, in the granulation tissue, as in the flaps of the wound in healing by the first intention, there are a great number of cells which come to nothing. Not only the millions of pus-cells on the surface, but also cells in the depths of the granulation tissue disappear by disintegration and absorption; it is very probable that even cells from the granulation tissue may pass back unaltered into

the vessels, as we shall see later on when treating of the organization of vascular thromboses.

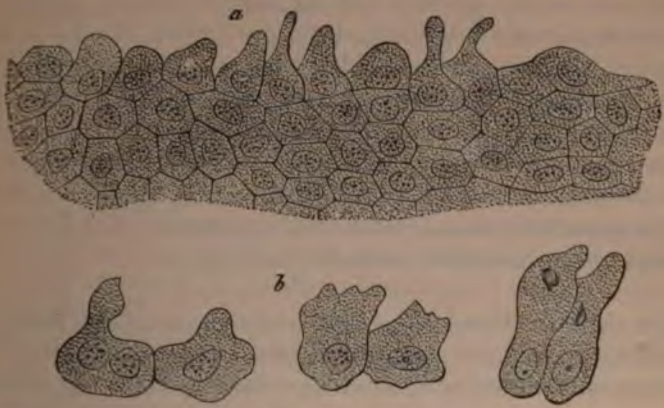
FIG. 10.

Fatty degeneration of cells from granulations. Granular cells. Magnified about 500.

As the cells retrograde, very minute fat-granules gradually form in them in continually increasing numbers, not only in the round cells, but also in those which have already assumed the spindle form; such cells, which are composed merely of the finest fat-globules, are generally called *granular cells;* they are often found in old granulations. If the granulation tissue is thus diminished by atrophy and escape of the cells, and at the same time the new formation of cells ceases, something else very important must now happen, namely, the gradual consolidation of the gelatinous intercellular tissue to striated connective tissue, which is produced by the constantly increasing loss of water carried off by the vessels, and evaporated from the surface; at the same time, the remaining cells assume the form of ordinary connective-tissue corpuscles. According to the opinion of other observers, the original intercellular substance entirely disappears, and its place is taken by the protoplasm of the granulation cells, which become transformed into fibrous tissue. With these changes, which advance from the periphery towards the centre, the secretion of pus on the surface ceases; at the immediate circumference of the wound, on the condensing granulation tissue, epidermis becomes developed, and rapidly separates into a horny and mucous layer; this formation of epidermis, according to J. Arnold, takes place by the division of a protoplasm, at first entirely amorphous, which is formed in the immediate vicinity of the existing border of epidermis. According to Heiberg, Eberth, F. A. Hoffmann, Schüller, and Lott, the

epidermis grows by the formation of shoots from the epithelial cells, which are nearest to the border of the wound.

FIG. 11.



Epithelial cells of the cornea of the frog sending out shoots at the margin of a wound (*a*). A few cells detached from such a border. Magnified about 600. After Heiberg.

Lastly, the superfluous capillaries must be obliterated; only a few of these remain to keep up the circulation through the cicatrix. With their obliteration the tissue becomes drier and more tough, and contracts more and more, and thus it is often only some years after that the cicatrix acquires its permanent form and consistence.

The whole process, like all these modes of healing, contains much that is remarkable, although its more minute morphological changes have been explained far better than before by recent investigations. The possibility, indeed the necessity, under otherwise normal conditions, of arriving at a certain typical termination is the most essential characteristic of those new formations which are produced by an inflammatory process. If the process of healing does not take this natural course, the reason will be, that either the general constitution or local conditions directly or indirectly interfere; or because the organ attacked is so important for life, the consequences of the disturbance so severely affect the entire organism, that there is death of the organ, or of the individual, due to this functional disorder. Every new formation, the result of inflammation, has always the tendency to advance to a certain point, to retrograde,

and to pass into the stationary condition of formed typical tissue, especially to be converted into cicatricial connective tissue; whilst other new formations have no such natural termination, but generally continue to grow.

Different as healing by the first and second intentions appears at the first glance, the morphological changes in the tissues are in both cases the same. You have only to imagine the borders of the wound in Fig. 3 (p. 80) to be separated, in order to obtain the same picture as Fig. 9 (p. 102): observation teaches in the simplest manner that this is really the case; if a wound almost healed by first intention, but not yet consolidated, be torn open, we have at once a granulating wound, which soon suppurates. You will often enough be convinced of this hereafter in practice.

The above-mentioned processes of healing by immediate adhesion, and by the formation of granulations, have been described as the effect of *traumatic inflammation*, and we have dwelt upon the fact that the traumatic inflammatory process has this marked peculiarity, namely, that the irritation in the tissue does not extend beyond the immediate neighbourhood of the injury, unless affected by any further accidental cause. I ask you carefully to bear in mind this very important limitation. Inasmuch as we have no precise knowledge with regard to the chemical changes and the action of the nerves in the inflamed tissue, whereas we are pretty accurately acquainted with the morphological processes, we confine ourselves for the present to these latter when we attempt to define and generalise our idea of "inflammation." I wish for a few moments again to refer to some of our previous observations (p. 72 and 81). "Inflammation" is a modification of the normal physiological processes in the various tissues of the body, a "disorder of nutrition" (Virchow), the histopoetic results of which you are now acquainted with, and you will subsequently hear of its destructive, deleterious effects. Originally a portion of the body was said to be "inflamed" if it was hot and red; inasmuch as it was then also usually swollen and painful, this term was employed to indicate those processes which were characterised by the presence of the above symptoms in combination. The word "inflammation" had its origin at a time, when, strictly speaking, there were no pathologico-anatomical notions; the earliest observers imagined that in this process there was something extraordinary going on in the tissues, that violent excitement took

place therein, and from the commencement this process has been mainly regarded as an intense exacerbation of the vital changes. But inasmuch as observers were as little able to comprehend it as we are now, they relied in part upon the symptoms which characterised the process, as we do now; in part upon the results and consequences of its action, as now-a-days; and thus, doubts not unfrequently arose as to whether it was still right to speak of inflammation when this, or that, symptom was absent, or not decidedly pronounced;—this is also the case with us. We know now, at any rate, that inflammation is not a thing which exists outside the body, and which, as such, gets into a part of the body, and there continues to exist, and which must be cast out like Beelzebub; we have, on the other hand, exact knowledge of the manner in which "Tumor, Rubor, Calor, Dolor" are conditions of inflammation; yet, although acute inflammation is generally recognised as such, and correctly designated by every layman, the difficulty still remains just as great, clinically, as well as anatomically, of giving a clear logical definition of the form of disease, known as "Inflammation." The word "Inflammation" is indeed so apposite for designating those processes for which it was at first chosen, that it would cause useless trouble to do away with it. We understand thereby the already minutely-described combination of processes in the tissues, which in our case are due to an irritant, in the first place purely mechanical, and acting once for all (the wound). How much hyperæmia, how much exudation, how much fibrinous formation, how many chemical transformations of tissue, what amount of new formation of tissue is necessary, in order that we must designate the process as inflammation, cannot be exactly defined; in the application of this word, there is much that is arbitrary, and many variations in the use of words. Objections have particularly been raised by surgeons as well as by anatomists, against designating as "inflammatory" the purely regenerative processes, that is to say, the new formations of tissue, which, in consequence of the disorders of nutrition produced by the injury, lead directly or indirectly to the adhesion of wounds, or to reparation of loss of substance, even though it be imperfect. If the process be regarded in a modern histological sense, it cannot well be separated from the inflammatory ones, however slight its extent and intensity may occasionally be. In a purely clinical point of view the distinction is easier to be made, for we certainly meet with numerous

cases in which there are none of the often mentioned four cardinal symptoms present in a marked degree at the borders of the wound; but the difference between a slight redness, swelling, and sensitiveness of the margins of the wound, and the most intense inflammation advancing over the whole of the injured part, is only one of degree. The use of terms has made another distinction; when a wound heals without any of the so-called symptoms of reaction (inflammation) we do not speak of this as inflammation, but use this expression only where inflammatory symptoms are very prominent in the injured part.

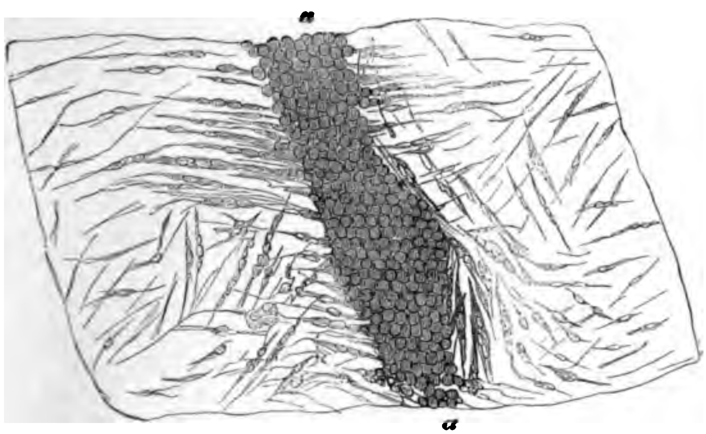
I thought it necessary at this stage to make you cognisant of these general considerations with regard to inflammation, the individual evident factors of which I previously brought before you in the changes of the vessels and tissue, in order that you may accustom yourselves to find your way through the difficulties of the subject. It will always be my endeavour in the course of these lectures, especially to explain to you the anatomico-physiological disorders as clearly as our present knowledge will allow, and at the same time to give you an historical account of the origin of the clinical theories and modes of expression which are now in use. Only in this way is it possible to fathom the nature and origin of our science; without such knowledge, you will be continually groping your way at the periphery of phenomena, and by confining yourself to single portions, you will fall into narrowness and hopeless dogmatism. Inasmuch as the great majority of men are intensely ignorant of subjects connected with the natural sciences, and seek and see in the physician rather the priest and idol, than the skilled adviser, you are sure to produce great practical results, even with a majestic display of medical ultramontanism; but you must then positively relinquish any intention of understanding, or certainly of promoting the development of mankind, a process which is ever advancing, and ever exhibiting greater freedom.

It is not the object of these lectures to show you on preparations, step by step, the morphological, microscopical changes of injured tissue; you will find opportunity for this in the practical work of pathological histology, but I will show you at least a little, so that you may not think that the processes which I have described to you can only be demonstrated on diagrams.

The cell-infiltration of the tissue after irritation by an incision

can be best seen in the cornea. Four days ago I made an incision *lege artis* with a lancet-shaped knife in the cornea of a rabbit, and allowed the wound to gape for a moment, in order that the irritation might not be too slight; yesterday the incision was visible as a fine line with slight milky cloudiness. I killed the animal, cut out the cornea carefully, and let it swell in pyroligneous acid until this morning; then I made a fine section through the wound, and cleared it up with glycerine.

FIG. 12.



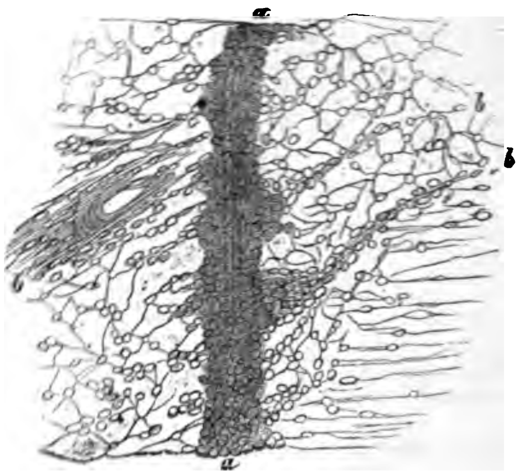
Incision of the cornea three days after the injury. *a*, *a*. The uniting substance between the two sides of the incision. Magnified 300.

In the above figure you see the connecting substance between the edges of the wound, in which there has been a considerable accumulation of cells between the lamellæ of the cornea, where the corneal corpuscles lie; these cells are here not so distinctly visible as when coloured by carmine, but the intermediate substance between the edges of the wound is very clearly seen; this consists almost entirely of cells, which would not, however, be sufficient to make the union firm, unless they were agglutinated together by a fibrinous cement. The young cells have apparently passed out of the edges of the wound from the fissures between the corneal lamellæ, and they probably do not originate in the connective tissue between the margins of the wound; this latter, on the contrary, is rather formed from them, under their influence. These fine corneal cicatrices, I may remark incidentally, subsequently clear up, so that they disappear, leaving scarcely a trace. The cells

which you see here in the preparation have probably all come from the vascular loops of the conjunctiva; they are wandering cells.

I must further remark, with regard to this preparation, that I have particularly selected it, because the intermediate substance is great, and contains very many cells. When very small incisions are made through the cornea with the sharpest knife, the intermediary substance is so slight that it is difficult to see it; the changes at the borders of the wound are then much less than in this case, and the fine cicatrix is invisible to the naked eye.

FIG. 13.



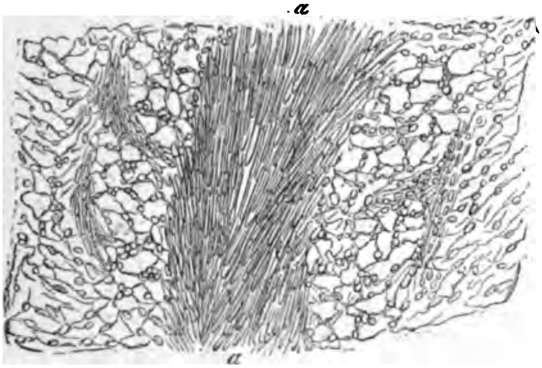
Incision made through the cheek of a dog, as seen twenty-four hours afterwards. Magnified 300.

You see here (Fig. 13) a transverse section through a recently united incised wound in the cheek of a dog, as it appears twenty-four hours afterwards. The incision is well marked at *a a*, the edges of the wound are separated by a dark intermediate substance, which consists partly of pale cells, partly of red blood-corpuscles, the latter belong to the blood escaped between the edges of the wound after the injury. The connective-tissue fissures involved in the wound, in which the connective-tissue cells lie, are already filled with numerous young cells, and these cells have already pushed themselves into the extravasated blood between the edges of the wound. This preparation has been treated with

acetic acid, and you therefore no longer see the striation of the connective tissue, but the young cells are more distinct. Look particularly at certain strands and lines, rich in cells, that extend from the wound towards both sides (*b b b*); these are blood-vessels, in whose sheath very many cells are infiltrated, which have wandered through the walls of the vessels, or are just in the act of doing so. As to the transformation of the coagulated blood between the borders of the wound, the "wound thrombus," we shall hereafter describe it more fully when treating of cicatrices of the vessels at the end of this chapter.

The following preparation (Fig. 14) shows you a young cicatrix nine days after the injury.

FIG. 14.



Cicatrix nine days after an incision, through the lip of a rabbit, healed by first intention. Magnified 300.

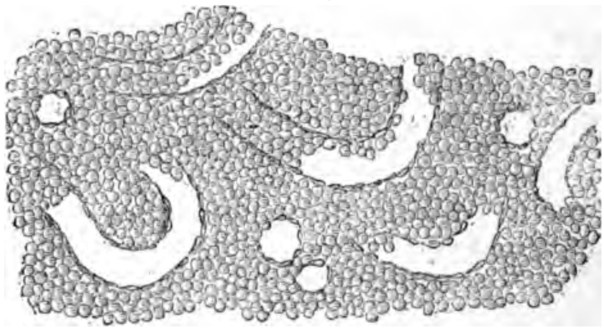
The connective substance (*a a*) between the edges of the wound consists entirely of spindle-cells, closely pressed together, which are most intimately connected with the tissue on both sides of the wound.

Fine sections cannot be made of granulation tissue just removed from a wound; it is generally a difficult object for fine preparations. If, however, it be hardened in alcohol, the section coloured with carmine and then cleared up with glycerine, you have a specimen like Fig. 15, p. 112.

The tissue appears to consist only of cells and vessels with very thin walls; as the whole tissue is shrunken by the alcohol we see nothing

here of the mucous intercellular substance which is always present, even if only in small quantities, in healthy, recent granulations.

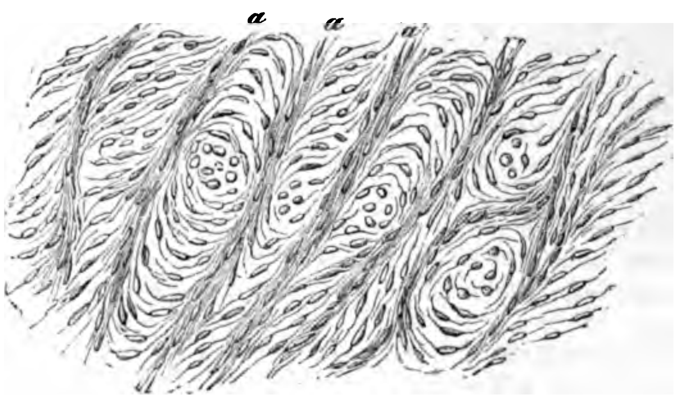
FIG. 15.



Granulation tissue. Magnified 300.

The tissue of the young cicatrix is particularly well seen in the following preparation (Fig. 16), which was taken out of a broad cicatrix following granulation and suppuration from the back of a dog, four or five weeks after the injury.

FIG. 16.



Young cicatricial tissue. Magnified 300.

The preparation has been treated with acetic acid, in order to show distinctly the arrangement of the connective-tissue cells, as they have been formed out of the granulation tissue; *a a a* are

blood-vessels partly obliterated, partly conveying blood; the connective-tissue cells are still relatively large, succulent, and manifestly spindle-shaped, the intercellular substance, however, is richly developed.

We must make injections if we wish to study the condition of the blood-vessels in the wound. This is somewhat difficult, and it often depends upon a lucky accident as to how soon we succeed.

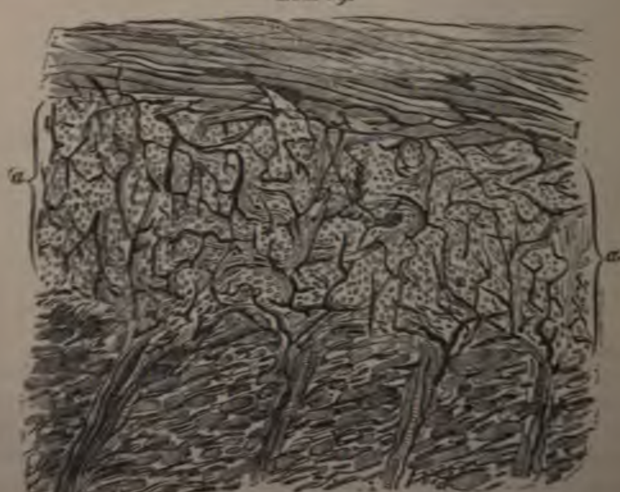
FIG. 17.

Horizontal incision through a dog's tongue, near the surface, made with a large knife. Front section through the tongue after injection and hardening, forty-eight hours after the injury. Magnified 70—80. After Wywodzoff. *a a*. Intermediate substance between the edges of the wound, consisting of fibrous-looking adhesive substance and extravasated blood. The section has passed through two layers of muscles crossing each other. Formation of vascular loops, with dilatation, in both borders of the wound. Commencing elongation of the knots and formation of shoots into the connective substance.

Fig. 18.

Similar section of dog's tongue as in Fig. 17. Cicatrix (*a*) ten days old. Anastomoses of the vessels from both edges of the wound everywhere visible. Magnified 70—80. After Wywodzoff.

Fig. 19.



Similar section of a dog's tongue as in Fig. 17. Cicatrix (*a*) sixteen days old. The vessels already considerably reduced and atrophied. Magnified 70—80. After Wywodzoff.

On this subject we possess the recent works of Wywodzoff and Thiersch, whose results in all essential matters agree partly with one another, and partly with those of my investigations on this subject. Wywodzoff, who operated on the tongues of dogs, gives a series of representations of the condition of the blood-vessels in various stages of the healing of wounds; a few of these I now lay before you without, however, going into the more minute details of the formation of vessels. (Figs. 17—21.)

FIG. 20.

Granulation vessels. Magnified 40.

FIG. 21.

Wound seven days old in the lip of a dog; healing by first intention. Injection of the lymphatic vessels. *a*. Mucous membrane. *b*. Young cicatrix. Magnified 20.

This (Fig. 20) is a preparation, from the human subject, of granulations where the vessels were tolerably filled by natural injection; the vascular loops are very close together and complicated at the surface; in the deep parts the vessels are all parallel.

In conclusion, here is a preparation of injection of the lymphatic vessels of a dog's lip (Fig. 21). You see that the young cicatrix on the seventh day, when it still consists almost exclusively of cells, has no lymphatic vessels. These cease immediately at the young cicatrix, where they only commence when the fibrillary connective-tissue bundles form. The granulation tissue also has no lymphatic vessels; where the inflammatory new formation, where the primary cellular tissue forms, the lymphatic vessels are for the most part closed, partly by fibrinous coagula, partly by new cell-formation. These observations have also been confirmed quite recently by Lösch, of St. Petersburg, in his observations on traumatically inflamed testicles.

LECTURE VIII.

General reaction after injury.—Traumatic fever.—Theories respecting this fever.—Prognosis.—Treatment of simple injuries, and of the injured.

GENTLEMEN,—You are now acquainted with the minutest processes, both superficial and deep, of the healing of wounds, so far as it is possible to follow these at the bedside, and also by means of experiments and with the aid of such microscopes as we at present possess.

As yet, however, we have not in any way referred to our *patients*, but if you have at all observed their condition, you will have remarked certain changes which up to the present time we are not altogether able to explain.

Probably towards the evening of the first day our patient will become restless and will feel hot; he will be thirsty and lose his appetite; he will have headache; during the night he will be wakeful, and on the following morning unrefreshed. These subjective symptoms become more marked in the course of the following day, and towards evening we feel his pulse; we find that it is more frequent than normal; the radial artery is tenser and fuller than before; the skin is dry and hot, and the temperature, when taken, is found to have risen; the tongue is rather coated and quickly becomes dry. You will already know what is the matter, the patient has fever. Yes, he has fever. But then what is fever? What is its cause? What relation have these objective and subjective symptoms—so remarkably different—to each other? But a truce to your questions! I can scarcely answer those you have already propounded.

By the word "fever" we understand that oft-described combination of symptoms which, in some shape or other, is almost always

present in inflammatory disease, and which is apparently dependent upon it; we know its exact duration and its course in various diseases, and yet its cause, though better known than formerly, is still not fully understood.

The febrile symptoms appear in varying degrees of intensity. Two of these are the most constant, increased frequency of the pulse and a rise in the temperature of the body. Both of them can be measured, the pulse by counting, the temperature by the thermometer. The frequency of the heart's beat may depend on a number of causes, and also on all kinds of mental excitement; it presents slight differences during sitting, lying, standing, and walking. We must, therefore, attend to a number of circumstances if we would avoid mistakes; we may infer that mistakes can be avoided by the fact that the frequency of the pulse has for centuries past successfully served for estimating the intensity of fever. Besides this, an examination of the pulse teaches many other things which it is important to know, viz. the quantity of the blood, the tension of the arteries, the irregularity of the heart beat, &c.; so that even now-a-days the pulse is not to be neglected, although we have other and better means for estimating the amount of fever. The other, and in many respects more accurate, method of estimating the intensity as well as the duration of fever, consists in taking the temperature of the body with a sensitive thermometer, the scale of which is divided, *after* Celsius, into 100 degrees and each degree into ten parts; it possesses this advantage also that the measurements, which, as a rule, should be taken at 9 a.m. and at 5 p.m., can be graphically given on a chart, thus allowing them to be easily and quickly perceived and read off. We are indebted to V. Bärensprung, Traube and Wunderlich for the introduction of this plan into general usage.

A series of observations on fever in the normal course of wounds (injuries) gives the following results: traumatic fever sometimes begins immediately after an injury, but more commonly on the second, third, or fourth day. The highest temperature attained, although this is rare, is 104°—105° F. (40°—40·5° C.); as a rule it does not rise above 101°—102° F. (38·5°—39° C.); simple traumatic fever does not generally last more than seven days; in most cases it only lasts two or three to five days, and in many cases it is entirely absent, as for instance in the small superficial incised wounds of which we have already spoken, and even sometimes after large operations such as amputations of the thigh and ovariotomy.

Surgical fever generally depends on the condition of the wound; it is essentially of a remitting type, and the decline may take place either rapidly or slowly.

If we are to consider surgical fever as a condition of reaction, we shall be led to the inference that the fever will be severe in proportion to the extent of an injury. If the injury be very small, there will either be no rise in the temperature, or the increase will be so small and so temporary that it will escape our observation. It might be almost supposed that a scale of injuries could be drawn up according to which the fever would be of longer or shorter duration, and of greater or less intensity, in proportion to the length and depth of the wound.

This conclusion, however, even with considerable restrictions, is only approximately correct. Some patients, after very slight injuries, get violent fever; while others even after extensive injuries have scarcely any. The causes of such differences lie chiefly in the fact that the healing of wounds may go on with more or less inflammatory action; *the more definite and the more intense the inflammatory symptoms around a wound, the higher will be fever; fever lasts just so long as the inflammation continues.* However, it does so happen that we can detect nothing about the wound, and yet the patient is feverish; in such cases it is probable that the inflammatory processes are deeply seated. It seems, too, as if individual idiosyncrasies, at present unknown to us, exert an influence on the amount and duration of traumatic fever.

Before we proceed further to examine what relation the state of the wound bears to the general condition of the patient, we must first briefly refer to this general condition. The most prominent, and physiologically the most remarkable, symptom of fever is the *rise in the temperature of the blood,* and the consequent elevation of the temperature of the body. On the explanation of these manifestations hinge all modern theories of fever. There is no ground for believing that to the already existing conditions which are constantly at work in an organism, for the purpose of maintaining an uniform temperature, any absolutely new ones are superadded during fever; it rather seems probable that a fever-temperature results from a change or modification of those conditions by which the normal temperature is kept up; they are no doubt easily and mutually transmutable. If you only consider that man and animals both maintain an almost identical temperature under the most

varying conditions of atmosphere, in summer as in winter, in hot as well as in cold climates, you will easily understand that the conditions of heat production and heat radiation are exceedingly variable, and within certain limits may even produce abnormalities in the temperatures resulting therefrom. It is *à priori* clear that an increase of the temperature of the body may result *from a diminution of heat radiation under an uniform heat production, just as well as from increased heat production under an uniform heat radiation* (other relations of these factors to each other are possible, but I pass them by so as not to confuse you on this difficult question). The final decision of this physiological question does not at present seem possibie; it might perhaps be accomplished by determining and comparing the amount of heat produced during fever and in the normal condition by means of so-called calorimetrical experiments either on large warm-blooded animals or on man; but at present there are many and serious obstacles in the way of such experiments. Liebermeister and Leyden have described methods of calorimetry which appear to me reliable, but I must not conceal the fact that both the methods and the conclusions of Liebermeister and Senator have been energetically contested. In regard to these questions, therefore, we are still too much thrown back on probabilities and hypotheses. As the production of heat chiefly depends on the oxidation of the constituents of the body, an increased amount of oxidation will naturally give rise to an increase of the temperature provided that the radiation of the heat remain the same. Now, as the amount of urea found in the urine is considered dependent on the combustion of nitrogenous materials, and since its quantity is generally increased during fever and the weight of the body rapidly decreases, as is known from the experiments of O. Weber, Liebermeister, Schneider and Leyden, it is believed on this account, and as a result of the above-mentioned calorimetrical experiments, that the combustion is increased in fever; in other words, that more heat is really produced than under normal circumstances, and more than can be utilised by the body in the same time. Traube holds other views regarding the production of this fever-heat; he believes that every fever begins with a vigorous contraction of the vessels of the skin, especially of the smaller arteries, and that thus the radiation of the heat is lessened; the heat is therefore stored up in the body, but is not produced in greater quantities; although these views are expounded by the

author with wonderful ability and acuteness and are confirmed by the researches of Senator, I, in common with other pathologists, am unable to accept them, and chiefly because the premisses—the contraction of the cutaneous vessels—can only be applied to those cases which begin with rigors, and a rigor is no necessarily constant symptom of fever. *In what follows therefore we shall assume that in fever there is an increased production of heat.* As to the chief source of this heat, whether it be in the blood or in the great abdominal viscera or in the muscles, we must let physiologists decide.

For us the question arises, How does the inflammatory process, and here especially traumatic inflammation, affect the temperature of the body? The question is variously answered.

1. At the seat of inflammation heat is produced in consequence of the vigorous tissue changes which are taking place; the blood passing through this part is thus heated, and then diffuses the abnormal heat so acquired throughout the body.

That this part really is hotter than a non-inflamed part is easily proved, especially in inflammations on the surface of the skin; but it does not prove that more heat is produced—it may perhaps only depend on the fact that more blood is passing through the dilated vessels of the part in a given time; if the inflamed part is not hotter than the blood which circulates through it, it is not probable that it produces heat. The researches on this point are not numerous, and are somewhat contradictory. The thermometric experiments of O. Weber and Hufschmidt on this point have given varying results; the temperature of the wound and of the rectum (which is generally that of arterial blood) were mostly alike, sometimes the former was higher than the latter, sometimes the reverse; but the differences were never very great, it was only a matter of a few tenths. O. Weber invented a new method, the thermo-electric; by means of some very elaborate experiments the matter seemed quite decided, namely, that the inflamed part was hotter than arterial blood, and that sometimes the venous blood coming from an inflamed part was hotter than the arterial blood flowing towards it. These experiments were repeated in Königsberg by H. Jacobson, M. Bernhardt, and G. Laudien, but with the final result of showing that no increase of heat was generated in the inflamed part; more recently Mosengeil has taken the subject in hand, his results on the whole correspond with those of Weber. With such contradictory results before us it seems impossible to

come to any conclusion on this point. We may, nevertheless, firmly lay down that in an inflamed part there is not produced so much heat as would appear necessary to raise the temperature of the entire body several degrees in one or two hours.

2. The irritation which is exerted on the nerves in the diseased part by an inflammatory process may be supposed to be conveyed to the vaso-motor (trophic) nerve centres; the excitation of these centres would cause an increase in the amount of tissue change, and thus an increase of heat.

This hypothesis, in favour of which there are some facts, as for instance the varying degrees of (so-called) febrile irritability, is a view I used to support, but seems to me to be no longer tenable; it is contradicted by the experimental researches of Breuer and Chrobak, who showed that fever might occur even after division of the nerves through which communication could be kept up between the peripheral injury and the corresponding nerve centre.

3. Owing to the very nature of the process, the tissues at the seat of the inflammation undergo extensive chemical changes; it is probable, therefore, that some of the products of these changes find their way into the blood either through the blood-vessels or the lymphatics; such products may easily give rise to organic decomposition in the blood, as the result of which throughout the entire blood mass an increase in the heat production would result. We might even admit a more complicated theory of heat production through the interposition of the nervous system, and one which in many respects would be more applicable, namely, that the blood, altered by the absorption of inflammatory products, reacts on the vaso-motor centres in such a way that a disturbance in the regulation of the heat supply is produced, and in consequence a rise in the temperature takes place.

The choice between these different hypotheses is difficult: each one at present has a certain show of probability. The latter theories have this in common, that a contamination of the blood by products from the diseased or injured part is taken for granted, and that they exercise a certain influence on the heat production, are, in other words, fever-producing materials (pyrogens). This has to be proved. It has been shown by the experiments of O. Weber, myself, and others, that in most open wounds, especially in contused wounds, shreds of connective tissue decompose and die; in many spontaneous inflammations the circulation ceases in some parts of the inflamed

tissues, hence decomposition sets in. Decomposing tissue, then, is an object which must be examined as to its power of setting up inflammatory action. If filtered infusions be injected into the blood of animals, they get violent fever, and not infrequently die with symptoms of collapse, somnolency, and simultaneous hæmorrhagic diarrhœa. The same effect is produced by injecting perfectly fresh pus: a less vigorous effect is produced by employing the juices and pus-serum, which may be squeezed out of an inflamed part: *the secretion poured out by a wound during the first forty-eight hours is especially active.* It will thus be seen that the products of the chemical decomposition of dead tissues as well as those of tissue changes in inflamed parts, produce pyrexia if they get into the blood. These products are of a very complex and varied nature; some of their elementary constituents are well known to possess pyrogenous attributes: thus by the injection of leucin, sulphuretted hydrogen, sulphide of ammonium, sulphide of carbon, and other products of decomposing tissue, fever may be produced, sometimes even by the simple injection of water. Decomposing vegetable matter also has a similar fever-exciting power. *It may be stated therefore that there is no specific fever-producer; but that the number of fever-producing substances is immense.* I will here mention that the stinking products of tissue decomposition are possibly the least noxious. I purposely distinguish the, for the most part, odourless decomposition products of acute inflammations, the poisonous nature of which we have just learnt by direct experiment, from such products of decomposing necrosed tissue as stink from the very first, though their pyrogenous influence may be the same. If a wounded man gets fever I conclude, whether the wound stink or not, that a phlogistic tissue-decomposition is taking place, and that its products have entered his blood.

Now that the pyrogenic action of inflammatory and decomposition-products has been proved beyond all doubt (you may explain it as you like), it becomes necessary to prove that they can be absorbed by the blood from the tissues, and to show how this takes place. For this purpose some of the before-mentioned material must be injected into the subcutaneous areolar tissue of an animal, where it can disperse itself among the meshes of the tissue; the result, as regards fever, is identically the same as though the fluid had been injected directly into the blood; the pyrogenic poison therefore is absorbed from the connective tissue. I must

just mention here that after a short time at the place where the injection of putrid fluid or of pus has taken place, there will be violent and often rapidly progressive inflammation. Thus, for instance, I once injected half a fluid ounce of putrid fluid into the leg of a horse: after the lapse of twenty-four hours the affected leg was swollen from top to bottom; it was hot and painful, and the animal had violent fever: the same result ensued in a dog, into which I injected some fresh non-putrid pus: the injection of the secretion of an amputated stump almost always causes gangrenous inflammation. This local inflammation, caused by the action of pus or putrid fluids, I call *phlogogenous*. Not all pyrogenic materials are necessarily phlogogenous: some are more so than others; it depends perhaps whether the poisonous potentialities of the putrid fluids, with the nature of which as yet we are not very well acquainted, are contained in larger or smaller quantities. Whether these pyrogenic matters get into the blood through the lymphatics or whether through the capillaries is not finally settled, though they may differ somewhat in these respects. There is much in favour of the view that absorption chiefly takes place through the lymphatics.

Samuel in his latest work on fever in general agrees with the etiology just given, and teaches that the increased temperature is due to an increased irritation of those nervous centres which preside over heat production. He declares against the acceptance of pyrogenous poisons, and urges much that is remarkable in favour of his views. He is of opinion that the altered condition of the blood, which is the very essence of fever, is always the same, although it is capable of being produced in so many various ways. In order not to allow the abstraction of blood or of water, or the injection of water or of blood, to count as pyrogenic causes in the widest sense, he introduces between the last-named inflammatory products and the nervous centre (which corresponds with the diseased part) an always uniform putrescent condition of the blood (*itio in partes*) which is itself the real pyrogenic cause, the very essence of fever.

We have yet to say something concerning *the course* of fever produced artificially in animals. The fever commences very early, often in one hour after an injection; after two hours there is always a very considerable rise in the temperature; for instance, in a dog whose temperature in the rectum was 102·2° F. (39·2° C.), I found it rise to 104·2° F. (40·2° C.) in two hours, and to

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only dangerous as regards its function, it is frequently dangerous to life also from its secondary consequences.

External circumstances, constitution, and temperament of the patient have also an important influence on the process of healing. Another source of danger lies in accidental diseases, which may affect the wound in its course, and of which, unfortunately, there are many; of these we shall speak in a future chapter. For the present you must rest satisfied with these suggestions, the further elucidation of which forms no inconsiderable part of clinical surgery.

We can give *the treatment* of simple incised wounds in a very short space. We have already referred to the union of wounds without loss of substance, and to the proper time for the removal of sutures, and this is about all that we can regard as directly influencing the process of healing. As in all rational therapeutics so here it is most important—(1) to remove all injurious influences which may tend to interfere with the typical course of the process, and (2) to watch carefully for any deviations from the normal standard, and to treat these therapeutically as they arise, if it is at all possible.

If we confine ourselves firstly to local treatment, we have no means by which we can materially shorten the process of healing, *per primam intentionem*, or by granulations, or reduce the time to one half or less. Nevertheless, most wounds require a certain amount of attention, although slight injuries have healed up over and over again without ever having been seen by a surgeon. The first condition for the normal process of healing is *absolute rest* of the injured part, especially if an injury extends through the skin into a muscle. It is necessary, therefore, in cases where the wound is at all deep, that the patient should not only keep his room, but also that for a certain time he should keep his bed, since it is obvious that movement of the injured part, especially if a muscle, will materially interfere with the healing process. The second important condition is keeping the wound and its neighbouring parts clean. It has often been observed that it is by no means necessary to cover wounds which have been sewn up. But if it is desired to cover such wounds, either because the edges are red and swollen, or because it affect a part of the body on which the patient lies, or which must be covered with the bedclothes, it may be done in various ways. It used to be done thus: the edges of the wound were smeared with fine oil—almond oil was considered the best—

and then a pad of lint soaked in oil was laid over it; this was changed daily until the sutures were removed, or a linen compress from four to six folds thick, soaked in water or lead lotion, was laid over the wound, covered with waterproof, and fastened on by one or two turns of bandage.

For some time past as an immediate covering for all recent wounds I have employed moistened gutta-percha tissue, then on this a wet compress, and over all (in order that it should not become dry) a piece of waterproofing (varnished paper, gutta-percha tissue, or oiled silk); and finally a thick layer of cotton wool (which has been boiled with potash in order to get rid of its grease, and to be thus made more absorbent) is laid on and the whole fastened with one or two turns of bandage. Such a dressing can be easily removed without rewetting and without giving any pain. For wetting the compresses, and also the fine gutta-percha tissue which is laid next the wound such fluids are used as are capable either of lessening the secretion from the wound, or of destroying the smell, that is, either antiseptic or deodorising fluids; and which also would destroy all possible infectious materials adhering to the dressings themselves (of which anon). In my own wards the following among other lotions have been in turns used:—solution of chloride of lime (as much lime as the water will dissolve), lead lotion, watery solutions of carbolic acid, carbolate of soda, sulphate of soda (about 10 per cent. strong). I have not been able to make out any great difference in the action of these fluids, and on economical grounds I have generally stuck to the solution of chloride of lime.

The frequency with which the dressing of a simple wound ought to be changed, entirely depends on the amount of the discharge: as a rule I advise that dressings, made according to the plan just given, should be changed twice a day for the first four days; or if the discharge comes through the dressing during the first or second day, it ought to be changed immediately. Made in this way it is not now necessary, as it was formerly, to wash the wound or carefully remove a number of strips of charpie to the great dread and discomfort of our patient: if under certain circumstances it become necessary to syringe out a wound—and it is necessary in the case of deep wounds, of which we shall speak presently—we should either use an ordinary brass syringe, or an Esmarch's wound-douche (irrigator), which consists of a cylindrical vessel about ten inches high and five inches across, having a short tap communicating with its lowest part, and to which

india-rubber tubing with a nozzle is attached: if an assistant raises this irrigator, it will act as a syringe. It generally suffices, when changing the dressings, to wash the part with a bit of wool: it is not at all necessary that all traces of pus should be removed.

In many cases this kind of dressing will answer for weeks: after awhile one dressing per day will suffice, aud later again a dressing every two or three days will be enough: cicatrisation goes on gradually, and the wound closes without any more ado. Quite irrespective of certain diseases of the granulations which we shall presently consider, it happens very frequently that under one uniform treatment the healing process will nevertheless come to a standstill, that for days together cicatrisation will cease to go on, while the granulation surface assumes an unhealthy appearance. Under such circumstances it becomes desirable to change the kind of dressing in order to stimulate the granulations anew. Such a temporary arrest in the process of healing is common in almost all large wounds. Under these conditions camomile fomentations may be ordered; that is, compresses of several thicknesses, soaked in the hot fomentations and wrung out from time to time, may be laid on the wound, or lead lotion may be applied, or the granulations may be painted with a solution of nitrate of silver (3—5 grs. to the ounce). If the wound is not very large, ointment dressings may now be tried: the ointments are spread very thinly on lint or old linen; the most useful are, king's ointment (unguentum basilicum), which consists of olive oil, wax, resin, suet and turpentine; or an ointment containing nitrate of silver (about 10 grs. to an ounce of any simple ointment, with an addition of a little Peruvian balsam). If the healing is almost complete, a little zinc ointment may be used, or a bit of cotton wool may be stuck on, and the wound allowed to heal-over beneath the scab.

A very peculiar, but in many cases an exceedingly useful, method for promoting the cicatrisation of a wound has been proposed by Reverdin. He discovered that a small bit of skin, cut off from the surface of the body by a fine pair of curved scissors, placed in contact with the granulating surface of a wound, and properly fastened on by adhesive plaster, not only would take root, but also that the transplanted epidermis would grow and become the centre of a cicatrising islet, from which the healing over of the wound proceeded just as it does from its natural edge. We have very frequently made use of this method of transplantation or grafting

the wound with epidermis in our wards, and seldom, indeed, without the wished-for result. Such grafts may be recognised by a somewhat sunken, drier, reddish area, which forms around them about the third day, when the adhesive plaster is taken off; these areas gradually increase, and then on the sixth or eighth day present a bluish appearance very similar to that presented by the cicatrising edge of an ordinary wound. I do not in any way under-estimate the practical value of this proceeding, and to me it is especially interesting as being an addition to our scientific knowledge. In it we have one of the most striking proofs not only of the self-dependence of cell life in the human tissues, but also and especially, of the facility with which the proliferative activity of the epithelium may be set at work (which in disease is due simply to a change in the nutritive materials which are supplied to it), while the papillary layer of the skin-graft does not grow. Thiersch, Minnich, and Menzel have made observations, from which it appears that epidermis may be successfully transplanted even eight hours, possibly longer, after death. The minuter details of the histological process of transplantation have been studied not only by Reverdin, but also, and very carefully, by Amabile and Thiersch. Czerny has proved that buccal mucous membrane with squamous epithelium and nasal mucous membrane with columnar ciliated epithelium can be successfully grafted on wounds, and that these epithelia, though they retain their special character for a short time, yet finally become converted into epidermis.

As regards constitutional treatment, we cannot do much with internal remedies to prevent or cut short the secondary fever. The patient should not overload the stomach after an injury, and so long as he is at all feverish he ought to take a slop diet. This he does almost spontaneously, for patients with fever rarely have any appetite; even after cessation of the fever the patient ought not to live high, but should rather take only such nourishment as can be easily digested while he is lying in bed or confined to his room, where he can get no exercise. If the fever run high, and the patient desire something beside water to drink, he can have acidulated waters, such as lemonade or effervescing mixtures. Of ordinary lemonade they soon grow tired, preferring phosphoric or hydrochloric acid with some fruit-juice in water, or currant vinegar, or water in which apples have been boiled, or toast and water (with a little lemon-peel and sugar); some patients prefer almond julep, or

a fruit ice dissolved in water, or barley water. While leaving such matters to the taste of your patients and the housekeeper in great part, you nevertheless will do well just occasionally to give a look to it yourself. The surgeon should be just as *au fait* in the kitchen and in the cellar as in the dispensary; it is no disadvantage even to have the reputation of being a *gourmet*.

LECTURE IX.

Combination of healing by primary and by secondary intention.—Deep wounds.—Open treatment of wounds.—Lister's method.—Coccobacteria septica.—Union of granulating surfaces.—Healing under a scab.—Diseases of granulations.—Cicatrices in different tissues—in muscle; in nerves, and their bulbous dilatation; in vessels, organisation of thrombus.—Arterial collateral circulation.

To-day I must first of all add a few words about certain deviations from the ordinary course of the healing process, which occur so often that one comes to regard them almost as normal, or, at all events, as not very infrequent.

It is not uncommon for the two methods of healing, by primary and by secondary intention, to be seen side by side in the same wound. For instance, a wound is completely brought together, and under certain circumstances you will observe that union by the first intention takes place at some places, while at others, on removing the sutures, the wound will open again, and only finally and gradually close by granulation.

It still more frequently happens that a large and deep wound, if partially or completely brought together, heals on the surface by the first intention, but goes on to suppurate deeper down. The reason why the wound does not heal completely along its entire surface, provided it is healthy and vigorous, lies herein, that either the apposition of its surfaces at the time of the first dressing was incomplete, or that blood or exudation gets in between the well-apposed surfaces; this exudation does not firmly coagulate so as to hold them together until organic adhesions have formed; on the contrary, it may decompose and may set up inflammation of the surfaces of the wound, which, under certain circumstances, may rapidly spread and give rise to most dangerous constitutional disturbance. The possible sequelæ of such injuries should induce

as to bestow especial attention upon the mechanical conditions of, and the probable chemical changes in wounds, which either from the first are deep wounds, or are likely subsequently to become such.

It is quite clear that in all operations where the skin is incised (in order, for instance, to remove a deeply-seated tumour, or to take away a piece of necrosed bone) a cavity must result, which in cases where the skin is again brought together and sewn up becomes filled either with blood or air, unless, indeed, this can be prevented by completely arresting the hæmorrhage, washing the wound, and accurately pressing the walls of the cavity firmly together. Still in wounds of an extremity, for instance, which penetrate the soft parts and reach the bone, the different layers of muscles alter their relative position to each other, so that the wound cannot be accurately closed.

Experience teaches that in such and similar cases extensive wounded surfaces, even if at first they can be brought into accurate apposition, are extremely liable to be again separated by subsequent hæmorrhage or fluid exudations, and that such materials shut up in a wound, the external edges of which have become adherent, are very apt to decompose. Meanwhile the region of the wound swells, often becomes painful, and an intense fever sets in. I will not anticipate by a description of the dangerous condition of septic infiltration, or of blood poisoning, what may result from this, but will only add that an early opening up of the wound and a free exit for the decomposing fluids often suffice to prevent the development of these processes. As to cause and effect in such cases there can be no doubt. Neither is there any doubt that a mere collection of blood between the tissues is alone unable to set up such dangerous conditions, for simple contusions very frequently occur without any such complications at all. Consequently it is the putrid decomposition of the contained blood, and the intensely phlogogenous and pyrogenous attributes of the earliest exudation (p. 101), which create these dangers. In the treatment of deep wounds, therefore, our attention must be chiefly directed to these points, (1) to prevent any accumulation of blood and exudations between the edges of a wound; and in case this should not succeed (2) to prevent the decomposition of thesefluids, in order that they remain as harmless in the deep wound, and ultimately be as harmlessly absorbed as if the skin were not broken.

Since the precautions against decomposition in the depth of a

wound would be unnecessary, if there were neither blood nor extravasation to decompose, so it is evident that the most important precaution to take is to prevent any collection of these fluids; obviously this could be most easily attained if deep wounds were not closed up at all, and if after all bleeding had ceased they were most carefully plugged with charpie, cotton wool, or any similar absorbent material, which should be renewed as often as it became saturated with the secretion from the wound. This method is hundreds of years old, and the results were satisfactory because no other methods were known. Nevertheless, the inflammatory reaction in wounds (although very much less than in the middle ages during the irritative treatment of wounds) was very great under this method, as we are now able to appreciate in consequence of improved plans of treatment.

There happened very frequently progressive inflammations, proceeding from wounds, which were at one time attributed to individual and constitutional causes, and then to the general influences of atmosphere, and especially of hospital air. It is only within the last twenty years that the correctness of the above-given treatment of deep wounds began to be questioned, and fresh methods resulting from different views to be sought after. This led to two entirely opposed plans of treatment; to the treatment without any dressing (open treatment of wounds), and to an absolutely air-proof method of closing the wound (method of occlusion). In the open treatment of wounds, which, except in injuries of the extremities, is beset with very great difficulties, the limb is so placed that the secretions from it may easily flow out into some suitable receptacle placed beneath it.

The wound secretion during the first two days is dark, blood red, and thin: during the third and fourth days it becomes light brown, then yellow, and very soon the pus serum will begin to separate from the solid, flocculent conglomerating pus-cells: this secretion will not begin to smell within the twenty-four hours at the ordinary temperature of the room unless masses of putrid and decayed flesh or necrotic tissue extend into the wonnd and so convey decomposition directly into it: this absence of odour in the fresh secretion from wounds must strike every one, who from past experience well knows how dressings soaked with discharges stink, which have been left unchanged for about twenty-four hours. The high temperature of the body to which they are exposed is, no doubt, the chief cause of this rapid decomposition. If any one, however, be disposed *à priori* to believe

that under this "open treatment" a retention of the discharge, with its evil consequences, is not likely to take place, he will easily be able on trying this plan to convince himself that the object of the above treatment is not by any means attained by an absolute non-interference or even by a purposeless supervision, and that not only the nature of the wound and its position may materially interfere with the exit of the discharges, but also that separate cavities may be formed within the wounds by local adhesions along its borders, as though a suture had been put in, and that within these spontaneously-formed cavities the retained wound-secretion, having decomposed, may give rise to exactly the same serious troubles as were experienced under older methods of treatment. A great deal may be done at an operation by making the flaps in such a way that the discharges may easily and quickly flow off: this in accidental wounds is not always very easy; it requires a considerable experience. As regards the formation of "pockets" within large wounds; we must as much as possible prevent it by daily breaking down all such adhesions or from the very first by putting into all angles and corners drainage tubes, through which any accidentally shut-in secretions may at once get out. (These drainage tubes, first introduced by Chassaignac, are made of vulcanised india rubber, they are of different sizes, and have holes cut at intervals along their sides. The expression "drainage" is an agricultural term: fields are rendered dry by laying down at a certain depth below the surface a series of porous tiles, into which the water percolates, and through which it is carried off into properly constructed ditches.) The results, obtained as the outcome of a careful and lengthened experience of this method of carrying out the open treatment of wounds, have far excelled all previous ones. I first became aware of this plan of treatment through the observations of Bartscher, Vezin, and Burow, now more than ten years ago: they fully coincided with the views which I had formed as the result of my clinical and experimental observations and researches on the poisonous properties of early wound-exudations, and I have, until quite recently, most carefully carried out this method of treating all deep wounds of the extremities, whether the result of incision or of contusion. But since several of the most esteemed German surgeons have asserted that Lister's very perfect antiseptic dressing gives still more brilliant results, I feel compelled to try the plan, however much I may differ as to the truth of the theories on which the plan of treatment is based.

There can be no doubt that it will be a great advantage to a wounded man, and also a triumph for our art, if we should succeed in making all deep wounds heal by the first intention, without any danger to the patient. In the open treatment of wounds it may certainly happen that the wound-surfaces having been placed in apposition heal by the first intention without any further artificial help; but on the whole it is seldom that this is the case, though partial adhesion is frequent enough, and in the absence of fever and of pain the wound does not require to be reopened. This has been accomplished either by the application of bandages, in order to press the cut surfaces together, or by sutures, running deeply through the underlying soft parts, which are thus held together: but although this has succeeded sometimes, it was dangerous in those not uncommon cases where, in spite of the pressure, the surfaces became separated by blood or exudations, and the latter not having any means of escape mostly decomposed; such dangers caused all conscientious surgeons to desist from this method. And when, a little later on, an effort was made to carry off these fluids by leaving open the corners of a wound and inserting oiled lint it was seldom found to have the desired effect. In my eyes Lister has the especial merit of having shown that all wound secretions are to be let out by inserting a number of drainage tubes into the wound, which are to be cut short on a level with its surface, even if the whole be covered in by an accurately adjusted dressing of absorbent materials and prepared wool. If blocking-up of the drainage tubes by the drying discharges be prevented by placing a bit of gutta-percha tissue (or, according to Lister, of silk protective) immediately in contact with the wound, we shall then have combined all the advantages of an open treatment, namely, the rapid discharge of all wound secretion with that of pressure, by means of which the adhesion of extensive raw surfaces with each other is so materially favoured. In order to prevent any of the discharge from decomposing in the dressings, and lest such decomposition should be conveyed to the interior of the wound, I think it safest to change the dressing frequently during the first few days, especially where there is much discharge. It is in the technical details, in the great cleanliness which is enforced at the operations, and the systematic rules which are laid down as to the dressings, that I see the great utility of Lister's method. Lister, however, was influenced by entirely different ideas in the construction of his

complicated system of dressing; like myself he has for a long time been convinced that it is almost always a process of putrefaction in the wound itself, which gives rise to dangerous and constitutional complications. But while I am of opinion that the putrefaction of the injured and gangrenous tissues and of wound secretions (a special decomposition of albuminoid bodies with the formation of pyrogenous and phlogogenous matters) is a chemical process, which necessarily results under certain circumstances in these tissues and without the coöperation of any new agencies, Lister, as is well known, accepts Pasteur's view, according to which putrefaction can only be set going through the influence of minute vegetable organisms, just in the same way that fermentation, according to Pasteur's theory, can only be commenced through the influence of the yeast fungus. In connection with the question of animate and inanimate ferments I must refer you, gentlemen, to organic chemistry; your teachers of this subject must explain to you these interesting and important subjects. In physiology you have become acquainted with the salivary, pancreatic, and gastric-juice ferments, which, although produced by the agency of cell-elements, are not themselves any longer living, and which, without possessing any of the mystic properties of an independent existence, act in a purely chemical manner; and in the same way I believe that a material may be formed during the necrosis of tissue, which to a certain extent may be regarded as the product of the last vital action of a tissue, which possesses some of the qualities of a ferment, and at the same time acts as a phlogogen, and possibly as an intensely poisonous one as regards the function of the circulating blood. It appears to me to be far from proven that the admission of minute organisms (vibriones, Pasteur's bacteria) is absolutely necessary for the production of such a material. That they are generally found in these fluids is perfectly true, but their presence can be explained by the fact that the germs of these little organisms are everywhere found both in air and water, and that they develop in putrefying fluids with especial ease and celerity.

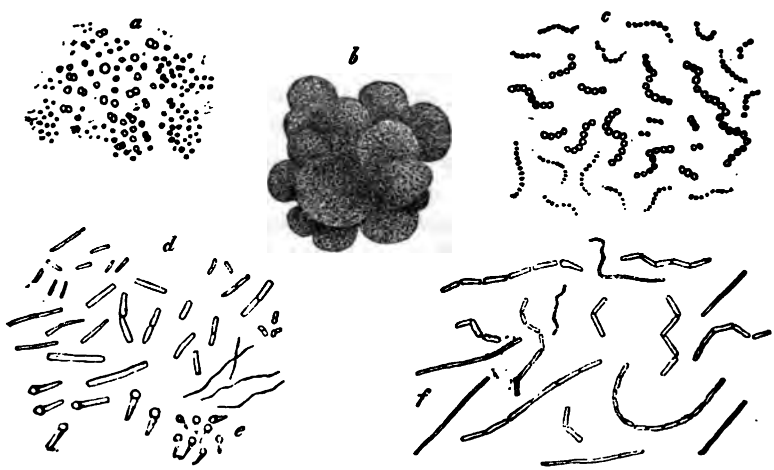
As we must often refer to these small organisms, about the importance of which there is, at present, so much discussion, I will just give you a short description of such forms as are most frequently found in putrefying tissues and fluids. They are partly the smaller spheroids (micrococcus, μικρὸς, little, and ὁ κόκκος, a germ), partly the smallest rods (bacteria, το βακτήριον, the

little rod), which are found either isolated or arranged in pairs, sometimes in chains of four to twenty or more links (streptococcus, ὁ στρεπτὸς, a chain, and κόκκος, a germ), often collected together in irregularly rounded and cylindrical masses by a kind of mucoid exudation (coccoglia, κόκκος, and ἡ γλία, or γλοιά, jelly).

These elements as regards their size are exceedingly variable; they vary in diameter from the smallest globule which is appreciable with the highest powers of the microscope to the size of a white blood-cell, and are sometimes moving, sometimes stationary. That these minute organisms are not of animal but of vegetable origin, and that they belong to the algæ, is now generally recognised, although their systematic classification in botany and their ultimate relation to each other is still under discussion; neither is their development as yet thoroughly explained, and even in most recent times assertions are not wanting that they result from "generatio æquivoca," or, as it is at present called, "abiogenesis" (that is, without the participation of any living germ). As a result of my own researches I am inclined to believe that all the above-mentioned forms belong to a plant which, seeing that it is composed of cocci and bacteria, and that it is generally found in putrefying fluids, I have named cocco-bacteria septica. The process of development of this plant I believe to be as follows: in dry air the dry germs of this plant are found, which, under the microscope, appear as the finest dust; when placed in water they swell and throw out, in greater or less numbers, small transparent globules (micrococci, Fig. 22 *a*). According to circumstances these take on the following different forms:—(1.) In their development by subdivision they exude a mucoid, tenacious material (glia), by means of which, like frog's spawn, they are held together in clusters (coccoglia or gliococci, Fig. 22 *b*). This form grows especially often on the surface of fluids as a very light brown tenacious film; it penetrates also into the interstices of a tissue, and it may be found too in fluids as whitish-grey flocculi; these varieties are always stationary. Under certain circumstances the glia round about the globules and cylinders becomes thickened into a membrane, and the cocci contents acquire motion and swarm out through a rent in the capsule (ascococcus, ἀσκὸς, a sheath). (2.) The individual cocci always subdivide in one direction, and some of them remain bound together by a delicate envelope like frog's spawn (Fig. 22 *e*). These streptococci are sometimes moving ones and swim slowly

across the field of the microscope; they are, however, mostly stationary; they are found both in fresh discharge from wounds and in pus also (and frequently in alkaline urine) in great quantities without there being any offensive odour either in the exudation or in the pus. Compared with the single micrococcus and the gliococcus, the streptococcus is that particular variety of the coccobacteria which is by far the most often found in decomposing wound-exudations and in the diphtheria of wounds (of which anon). In a state of absolute rest the streptococcus may form long threads running parallel with the surface (a so-called fungus bed [Pilzrasen]); this, however, in the living subject occurs but very

FIG. 22.



Micrococci, Bacteria, &c.

seldom, and it is very difficult to manage to see it under the microscope. (3.) The cocci develop into little rods, into bacteria. Each bacterion grows lengthwise and then subdivides transversely; by means of this form of growth chains of bacteria are formed (Fig. 22 *f*), which also are either still or moving, and may form a fungus-carpet like the streptococcus; or the subdivision of the bacteria may be complete, so that only single ones, or at most two together (diplobacteria) result, which are sometimes absolutely at rest, but very much more frequently are exceedingly active in their

movements. In some kinds of fluid the subdivision of bacteria takes place with great rapidity, and the rods are then much smaller; they, in fact, become almost square; finally, they appear rounded off, so that the differences between cocci and bacteria are characterised by an almost innumerable variety of transition forms. Bacteria thrive badly in wound-exudation, in pus, or stinking blood; they are formed, however, and remain stationary in all the fluids of the dead body, and in watery infusions of all tissues; in the latter they are very active in their movements.

All these vegetations require water in considerable quantity for their rapid development, and organic substances, especially nitrogenous compounds, for their assimilation; they can bear a partial withdrawal of their water for a short time, but if they are completely dried then they die; even if they again partially swell out in water they seem to have lost their vegetative activity. They can withstand a temperature of some degrees below freezing, and one almost at a boiling-point of water without dying, but the heat of boiling water kills them. They can vegetate in fluids and moist tissues, which are completely shut off from atmospheric air until they have used all the air dissolved in these fluids, and then, unless more air is let in, the coccobacteria vegetations die, as they are quite unable to decompose water or any organic combination whatever. Under such circumstances many of these coccobacteria vegetations on the evaporation of fluids, which is very frequent in nature, might get into the atmosphere and hence be conveyed all over; but in dry atmosphere these vegetations dry up, die, decompose, and once again become organic, but now no longer organisable dust. It is provided that this shall not be so. As in the case of many still-water algæ which possess the same vital characteristics and are not free from the danger of drying up, so also in single elements of coccobacteria, a quantity of very concentrated protoplasma runs together under certain conditions into a darkly contoured shining globule which by the above-mentioned properties may be easily distinguished from other cocci, if it be possible to distinguish them with certainty from firm fat-globules. These globules possess the properties of fungus spores and very resisting seed granules; they may be completely dried, exposed to far below zero, or heated over 212° (100° C.), and shut off from the atmosphere for any length of time without losing their power of germinating; on this account they are called "Dauersporen" (resting-spores). They develope according to my

observation under definite conditions very certainly and not seldom into bacteria; nevertheless they sometimes form into masses of coccoglia. I am unable to say whether single globules of streptococcus ever changed into "Dauersporen." These "Dauersporen" are the dry-air germs with which we commenced; for their development they require a quiet resting place either in or upon a fluid or on a very moist tissue. I have now given you in this short review a sketch of the results at which I have arrived in a morphological sense as the result of my researches on this subject. I must, however, especially mention that a more extensive examination of these observations has not yet been made by botanists, and that I am comparatively isolated in my views and at variance in them with many other pathologists, who have earnestly occupied themselves with this subject. Most of them not only believe that each one of the forms described by me is a separate plant, but distinguish many species of each kind, especially according to the diseases which they cause. I must also call your attention, for the sake of clearness, to the fact that most pathologists regards these algæ as fungi, and others call all the above-described varieties shortly "Bacteria."

On these minute organisms, then, according to Pasteur and Kisber, putrefaction depends, at least that kind of putrefaction the products of which are both constitutionally and locally poisonous. If we succeed in preventing their admission into wounds and wound secretions, then there will, according to this view, be no more putrefactive decomposition of these secretions, even if some be retained deep down in a wound. Accordingly Lister prescribes a number of rules at an operation, and at subsequent dressings, all of which have for their object the destruction of the germs of bacteria which may possibly get in either from the hands of the operator or his assistants, or from the sponges, instruments, and dressings which he uses, or from the surrounding air, at the time of operation and of each dressing. The operator and his assistants first of all carefully wash their hands with soap and water, and then rinse them thoroughly in a 5 per cent. solution of carbolic acid; the skin over the part to be operated on is also carefully washed in the same manner and then wetted with the carbolic solution; all instruments, sponges, and dressings which are to be used are placed in carbolic solution, by which it is supposed that all the coccobacteria germs are destroyed. In order to prevent any such germs getting in from the atmosphere, a 2 per cent. solution of carbolic acid is sprayed, by means

of a special apparatus, over the wound, during the operation, and the application of the necessary dressings; by means of this "spray" the air surrounding the wound is carbolised, and the pulverised fluid settles in the form of a very fine and constant rain on the surface of the wound. We have already spoken of the occlusive dressing which, on account of the above-mentioned peculiarities, has received the special name of "antiseptic dressing," although the open method of dressing wounds and many other methods are equally antiseptic in their action. It would not be wise in this place to go more into the details, as our scope is the examination of principles. This apparently complicated system of Lister can be more easily carried out in practice than would appear from the description; for the author has definite grounds for each act and rule of the process, and there is nothing either arbitrary or mysterious about it.

If we inquire into the practical results of this method of treatment we mostly hear it favorably, and by some even enthusiastically spoken of. Although my own experience of Lister's treatment of wounds is not yet very great, I am, nevertheless, able to recommend it on the whole as very practical; it is no doubt capable of more extended use than the open treatment of wounds, but whether the results of the latter in wounds of the extremities are equal to or excel those obtained by Lister's method is still a matter of dispute. On the whole, I can most strongly recommend you to exercise yourselves in the principles and practice of Lister's treatment, for by it you will certainly get most favorable results.

It is quite another thing, however, when we come to inquire into the correctness of the theoretical views which Lister holds, and to examine whether he accomplishes by this method of operation and of dressing what he strives for; it has been amply proved that the same forms of coccobacteria are just as frequently found in the secretions of those wounds which have been treated after Lister's plan, with brilliant results and without any constitutional disturbance, as in the secretions from wounds treated on the ordinary plan. From this, then, it may be inferred (1) that the presence of these organisms in the discharges from wounds does not *ipso facto* account for their phlogogenous and otherwise poisonous properties; (2) that Lister's method of dressing affords no guarantee for the destruction of the coccobacteria germs. On this subject it may no doubt be said, that it is not yet certain that these germs get into a wound *only* from without; it is quite possible that they are constantly being taken

directly into the blood from the inspired air; and while under normal conditions they do not develope, yet that they may grow in the discharges from a wound. If this be possible, then the theory of Lister's method, in so far as it chemically deals with germs, no longer holds good. I therefore believe that in all those cases, certainly not very common ones, in which coccobacteria germs have been found in deeply-seated but absolutely closed wounds, which have never communicated with the air, no other explanation of their presence is possible than the one I have just given. This variance between the theory and practice of Lister's dressing, apart from the fact that to practise it exactly is very expensive, that carbolic poisoning more or less pronounced is very common, and that it not infrequently causes a dermatitis which is very painful and troublesome to the patient, has led to a constantly decreasing strength of the carbolic solutions, and even to a substitution of other less irritating antiseptics (salicylic acid, by *Thiersch;* sulphide of sodium by *Minick*). Further, many variations in the method of dressing have crept in (Volkman, Bardeleben), the spray has been dispensed with and the wound after the completion of the operation has been washed out with concentrated antiseptic solution, &c., so that Lister's dressing has already been greatly modified, and yet each modification, it is said, gives as favorable results as the original method. All this tends to confirm me in the opinion I formed, on first hearing of this plan of treatment and its results, and which I expressed at the commencement of these observations. It is this, that the scrupulous cleanliness of and the very careful draining away of all the discharges from the wound are by far the most important factors in the success. Those surgeons more especially think very highly of this procedure, who formerly paid little attention to these points and who, according to old tradition, handed over the subsequent dressings to the dirty hands of nurses or to careless students; now every precaution as to cleanliness in each case is carefully and systematically adopted. The doctrine, too, of local infection is ever spreading, and is being energetically advocated; it has directed our attention more and more to the necessity for a rational treatment of wounds, and has done much to pave the way for the open treatment, for Lister's method, and for the introduction of antiseptic applications.

Gentlemen, we were led to make these observations on the peculiar conditions of deep wounds by the consideration of different combi-

nations of healing by the first and by the second intention, and now we revert back again to these slight deviations from the normal course of healing. I must, however, mention a kind of union of the surfaces of a wound which consists in the adhering together of two well and closely apposed granulating surfaces. This kind of healing, if you like, you may call healing by the third intention: very seldom does it happen spontaneously. The reason of this is easily understood: the surface of the granulations is constantly secreting pus, and so long as this is the case the two surfaces are only apparently in contact, for between them is a layer of pus. One occasionally succeeds, it is true, in preventing any extensive formation of pus by pressing the two granulating surfaces together, and then they may adhere together; this is best accomplished either by drawing the edges of a wound firmly together by means of good adhesive plaster, or by the application of deep sutures; and for this purpose it is well to choose metal ones. Unfortunately, even with these measures, the attempt to bring about a rapid union so seldom succeeds that it is only very exceptionally employed. The best results are obtained by putting in secondary sutures made of metal; they should be placed at least half an inch from the edge of the wound, and not applied until the sixth or seventh day, by which time the tissues will have become firmer and harder, and the sutures will therefore cut through less quickly.

Lastly, there is another kind of healing, namely, healing of a surface-wound beneath a scab. This is only seen at all frequently in little wounds, which do not secrete much pus, for only in such cases does the pus dry up on the surface of the wound into an adherent scab; in profuse suppuration the surface of the pus may dry owing to the evaporation of its water, but so long as fresh pus is being constantly poured out beneath, it is impossible to get an adherent scab. If, however, such a scab does form, the granulation tissue grows less copiously beneath it, possibly on account of the pressure of the hardening scab, and because it is less moist; and thus the epidermis beneath the scab is more easily regenerated. A small wound may cicatrise completely before the scab falls off.

The surface of the granulations, especially of large wounds, not infrequently assumes a different aspect to the normal appearance. There are certain diseases of granulations the characteristic forms of which I will now briefly sketch, although the varieties are so

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conditions of

scab will quickly form, and within twelve to twenty-four hours, or even less, fall off. You must repeat this mild cauterization according to circumstances, until, in fact, the surface of the granulations is quite even. Another and very good method is to bestrew the wound with powdered red oxide of mercury (Hydrargyrum oxydatum rubrum); this must also be repeated daily in order to improve the granulating surface. Pressure by means of strapping occasionally acts very well. If the granulations be exceedingly large and prominent, you will succeed most quickly by removing a portion of them with the scissors, or with a sharp spoon; if there be any hæmorrhage it is readily arrested by means of a bandage.

(2) *Erethetic granulations.*—Under this term we refer to such as are characterised by great pain on the slightest touch; they are generally very prolific, and easily bleed. They are an exceedingly rare variety. In highly marked erethismus of the granulations they are so sensitive that even the slightest touch cannot be borne, and any and every kind of dressing is painful. Minor degrees of sensitiveness are common enough. On what this depends is not very clear, as granulation tissue itself does not contain any nerves; in most cases handling them causes no pain; sensation is the result of pressure conveyed from them to the subjacent nerves. In the cases above referred to, of great tenderness the nerves on the floor of the wound have probably degenerated in some peculiar way; perhaps their finest endings have become thickened *en miniature,* as we shall presently learn the larger nerve-trunks do. More accurate observations on this subject would be very valuable. We occasionally observe similar conditions in the cicatrices of large nerves; we shall have to speak of this subject later on. In order to allay this very troublesome pain, which not only interferes with the healing but also greatly irritates the patients, you must first try mild ointments, such as almond oil or simple ointment (consisting of oil and white wax), or poultices made of boiled oatmeal or linseed-meal, or warm fomentations. Narcotic fomentations or poultices made with the addition of belladonna or hyoscyamus leaves are of no material benefit. If this does not avail, then do not hesitate to apply to the painful places, or even to the entire granulating surface, either caustic (nitrate of silver or caustic potash) or else the actual cautery, having previously given chloroform, or you may scrape off the entire mass of granulation with the sharp spoon. If this great sensitive-

ness and irritation be due to hysteria or anæmia, then local means will not be of much avail; you must endeavour to reduce this irritability by internal remedies, such as valerian, asafœtida, iron, warm baths, &c.

(3) It further happens in large wounds, and especially also in fistulous granulations, that a membrane will form over some portion of the granulating surface, which may be easily detached, and which on a closer examination is found to consist of pus-cells, extremely adherent to each other. Although I have occasionally found between the cells some areolar filaments, yet this is not always the case, and we must therefore suppose that the cell contents, the protoplasm itself, is transformed into fibrine, as occurs in true croup, and especially in the formation of false membranes on serous surfaces. Here, then, we have to deal with *croup of granulations*. The croupous membrane is re-formed in a few hours after its removal, and this goes on for several days together, till it either disappears spontaneously or finally ceases as the result of treatment.

Very similar white spots are sometimes found on large granulating surfaces, which are not the result of fibrinous deposit either on or in them, but are probably due to plugging of local blood-vessels. Under unfavorable circumstances both these conditions may terminate in a destruction of the granulations, as also in true diphtheria of the wound, of which I shall speak later. Fortunately, however, it rarely goes on to this stage, and after awhile the appearance of the sore begins to improve and healing takes place in the usual manner. If such a disease of the granulations is accompanied by swelling, increased pain and feverishness, then we have really to do with an acute inflammation of the wound; the flabby granulation material becomes coagulated into a fibrinous mass, and the surface of the wound looks yellow and greasy. I shall refer to the causes of such secondary inflammations of wounds when treating of contusions later on.

It cannot be denied that the entirely local manifestation of fibrinous exudations, both superficial and interstitial, strongly supports the view which Virchow has enunciated for croupous processes generally. It was formerly held that the blood was over-rich in fibrine in all inflammatory croupous processes, to which the ordinary form of acute inflammation of the lungs and pleura essentially belongs; in consequence of this the increased quantity of fibrine, escaping from the capillaries in a fluid form, coagulated

partly on, partly in the substance of, the inflamed tissues, and so led to the formation of these pseudo-membranous deposits. Virchow, on the other hand, started the view that the tissues, owing to the inflammatory processes going on within them, acquire the power of coagulating the exuded fibrine with which they are infiltrated. I cannot here more fully enter into the various grounds on which Virchow bases this view, but will content myself by pointing out that in the present case of fibrinous exudation on a granulating surface it cannot be a question of a sudden or temporary fibrinous condition of the blood generally, but is evidently the expression of some purely local process, which may be easily stopped by purely local means. According to the already mentioned observations of A. Schmidt we may conclude that under certain forms of irritation the tissues throw out more fibrogenous material than usual. Virchow had previously pointed out that by long-continued irritation simple serous exudations might become fibrinous or croupous. If cantharides be applied to the skin a blister full of serous exudation is quickly formed, that is, the epidermis is raised from the derma by a rapidly formed serous exudation from below; now, if this blister be removed and the cantharides reapplied, in many cases the surface becomes covered after a few hours with a fibrinous layer, which will be found to contain innumerable newly formed cells, indeed to be composed of them entirely. The same result may be obtained by applying the blister to an already inflamed surface or to a recent cicatrix.

The treatment of croupous inflammation of granulations is purely local; we should carefully look for any possible source of fresh irritation and endeavour to remove it. Let the false membrane be removed daily and touch the exposed surface with nitrate of silver or paint it with tincture of iodine; under this treatment the abnormal condition of the granulations will soon disappear.

(4) Besides the above-mentioned diseases of granulations there is a condition of complete relaxation and collapse in which they present an even, red, smooth, shiny surface, from which the tuberculated granular appearance has completely disappeared, and from which, instead of pus, there is secreted a thin watery serum. This condition of granulations almost always recurs *sub finem vitæ;* you will constantly find it, as I have already remarked, on the dead subject.

It is necessary to add something about cicatrices, as to their

secondary changes, their proliferation, and their appearance in different tissues.

Linear cicatrices of wounds which have healed by the first intention seldom undergo any subsequent degeneration. Large broad cicatrices, if situated immediately on bone, very often open again, because either from traction, a slight blow or abrasion, the epidermis, which at first is very tender, gets torn off, and a superficial sore, an excoriation of the cicatrix, is produced. Sometimes it happens that the young epidermis is raised into a blister by an exudation from the vessels of the cicatrix, into which also slight hæmorrhage may occur, so that the vesicle becomes distended with blood-stained serum. After removal of the bleb there remains an excoriation, as after simple abrasion of the epidermis. This abrasion of the scar, if it recur often, is exceedingly painful to the patient. You may best guard against such an accident by advising your patient to protect it either with cotton wadding or with a bandage. But if an excoriation has occurred treat it with very mild and simple measures, such as sweet oil, glycerine, cerate, zinc ointment, or lead plaster. Stimulating ointments in such cases only enlarge the wounds, and on that account are to be avoided.

When the granulating surface is once covered with epidermis, as already stated, a retrogressive change to firm connective tissue takes place, and it atrophies. In rare cases, however, the cicatrix takes on an independent growth and develops into a firm connective-tissue tumour. This only occurs in small wounds, which have suppurated for a long time and become covered with spongy granulations, and over which the epidermis has closed in some exceptional way.

You know that it is the custom to pierce the ears of young girls, so that they can wear earrings. This small operation is done with a large needle either by the mother or the goldsmith, and immediately afterwards a small earring is introduced into the puncture. As a rule, the small hole quickly cicatrises, and the ring prevents its closing. In other cases inflammation and suppuration sets in; the ring may even cut through the lobule in consequence of the long-continued suppuration, fungating granulations develop around the points of entrance and exit, and finally the attempt is given up and the ring removed. The openings now usually close immediately; sometimes the granulations cicatrise and the cicatrix continues to grow, and on each lobe there forms a small connective-tissue tumour —a fibroma (or keloid, from κηλίς, a stain, and εἶδος, like), which

resembles a thick shirt-button drawn into the orifice of the ear; as in other tumours, there is independent growth. If you examine these tumours you will find them perfectly white on section and of a fibrous appearance; like the cicatrix itself, they are made up of a connective tissue, rich in cells; they are, in fact, a proliferation, a hyperplasia of cicatrix. I have frequently observed these changes in the ear, and Dieffenbach also refers to a case in his 'Operative Surgery.' I have also once seen these tumours in the neck; they occurred at the orifices of a seton, and each one was as large as a chestnut. They must be carefully removed with the knife, and any subsequent granulations must be checked by the application of nitrate of silver.

We have hitherto confined ourselves for the sake of simplicity to a description of the formation of granulations and cicatrices in connective tissue; we must now refer to them as they occur in other tissues.

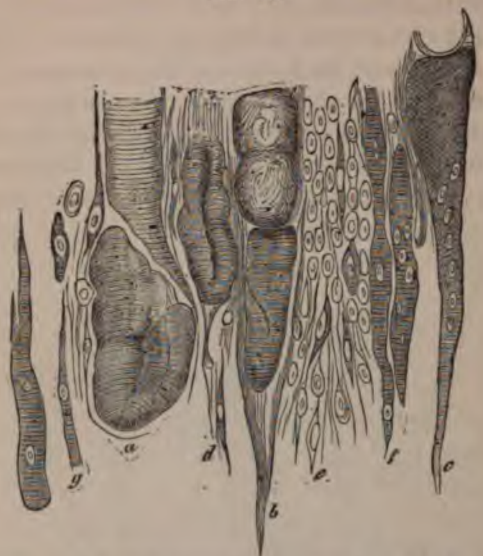
FIG. 23.

Cicatrix from the upper lip of a dog; connective tissue at *a*; the divided muscular fibres are for a short distance atrophied, and then terminate conically. Magnified 300.

The cicatrix in muscle is at first almost entirely connective tissue; at the ends of the primitive muscular fibres a degeneration first takes place, then within certain limits the production of cells; the fibres next become rounded off, sometimes club-shaped, more frequently conical, and the extremities of the muscular fibres unite with the connective tissue of the cicatrix, just as they do with the tendons; the cicatrix in the muscle, in fact, becomes an *inscriptio tendinea*.

For my own part, I have only studied wounds of muscle which have healed *per primam*, and I have never seen anything which I could regard as a re-formation of muscular fibres. O. Weber has observed in a slight degree a new growth of muscular fibre in suppurating muscles; this seems to occur especially in granulating muscle and in certain forms of tumours.

FIG. 24.



The extremities of divided muscular bundles from the biceps of a rabbit eight days after the operation; *a*, *b*, *c*, old muscular fibres; *a*, the contractile substance rolled up and heaped together; the same in the fibres above *d*; *a*, *b*, the same, with the sarcolemma drawn out to a point; *c*, a number of young cells passing into the conically shaped sarcolemma, between them there is a delicately striped substance; *d*, connective-tissue granulations; *e*, the same with young free muscular fibres; *f*, two young flattened muscular fibres; *g*, ditto of different size and isolated. Magnified 450 times. After O. Weber.

Weber is of opinion that young muscular fibres are principally formed by division of the protoplasmic substance of the extremities of the old muscular fibres, but considers it impossible to prove that muscular fibres may not also be formed from other young cells. As the result of his examination of older muscular scars, he believes that regeneration is constantly going on and that in process of time it becomes more complete than is generally supposed. Maslowsky

believes in the transformation of wandering cells into muscular cells, but I do not think the results of his experiments with cinnabar are sufficient to prove his point.

Gussenbauer has affirmed that a destruction of the contractile substance of the muscular fibres generally takes place after the injury, and that new young muscular elements are developed—on the same plan as in fœtal development—almost entirely out of the cells contained within the old muscular fibres; the amount of the new formation depends on the kind and duration of the irritation.

FIG. 25.

The process of regeneration in striped muscular fibre after injury. Magnified about 500 times. After Gussenbauer.

When a nerve is simply divided the cut extremities, by virtue of their elasticity retract; they swell slightly, and then by a fresh development of true nerve-tissue they subsequenly reunite, so that the nerve power is again re-established through the cicatrix. In large superficial cicatrices new nerves develop, and even after the excision of portions of skin, the distant parts having been brought together

and united, new nerves will develop through the cicatrices and after a time complete power of conduction will be again acquired, as may frequently be seen in plastic operations. These facts are most remarkable and physiologically quite inexplicable. Consider how remarkable it is that the nerve-fibres, motor and sensory, should again become united, that, as we are bound to suppose, the self-same fibrils should become attached to each other as was the case before the injury, in order that conduction and localisation of sensation be not in any way interfered with, such as is really the case!

Fig. 26.

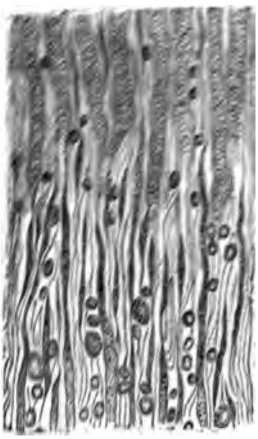


Fig. 27.

Regeneration of nerves.

Fig. 26.—From a rabbit fifteen days after section; young spindle cells in the nerve-ends, developed from the connective tissue, and ultimately connected with the neurilemma.

Fig. 27.—From the frog ten weeks after section. Development of young nerve cells from spindle cells. Multiplied 300. After Hjelt.

We cannot go more into details respecting these facts; I will only mention that the minuter processes, which have been most carefully studied by Schiff, Hjelt, and others, are somewhat as follows. There is first of all a degeneration of the medullary sheath, possibly also of the axis cylinder, for a certain distance from the injury, which is quickly followed by the production of cells in the neurilemma; these develop into spindle cells and spread into the tissue which intervenes between the nerve-fibrils, and which extends also between the cut extremities of the nerves. From these cells, as

in the embryo, new nerve-fibres are developed; the fibres, which at first are very pale, are provided with a medullary sheath, and ultimately cannot be distinguished from ordinary nerve-fibres.

The most recent researches on the ultimate significance of wandering cells in tissue regeneration, as also some original investigations on the reproduction of nerve-substance in tadpoles' tails after injury to the nerves, have shaken my former belief that such regeneration proceeded from the spindle cells. It now seems to me much more probable that the divided axis cylinders grow out into young nerve-fibres; that the long-shaped spindle cells, which are undoubtedly present in the nerve-callus at certain stages of the process, either belong to the connective tissue of the neurilemma, or that they are detached nucleated fragments of young nerve-filaments. This view, the correctness of which I have not been able to verify by further experiments, appears to me to be very near the truth.

The recent researches of Neumann and Eichhorst corroborate earlier observations as regards the immediate effects of division, but they show that the young nerve-filaments really grow directly from

FIG. 28.

Nerves of rabbit; *a*, seventeen days, *b*, fifty days; *c*, frog's nerve thirty days after division. Multiplied about 600 times. After Eichhorst.

the axis cylinders of both the central and the peripheral extremities, that they meet and then grow into each other, just as primitive capillaries join with other vessels, and so become channels of communication between them (Arnold). The process of repair in

injured nerves, then, corresponds exactly with that in injured muscles. New young filaments branch out from the extremities of primitive fibres both in muscles and in nerves (fig. 28, *a*, compare with fig. 25).

Hence, then, it is now certain as regards muscles, vessels, nerves and epithelia, that they are not regenerated from a heaping up of proliferating connective-tissue-cells, nor from wandering cells, but by a budding out of their own tissue, that is, from cells which spring from the protoplasm of their own tissue. It seems possible that connective-tissue-cells also, at least such as still contain protoplasm, send out offshoots in a similar way to the injured surface, in which nuclei ultimately develop, just as is the case in the growing nerves in the tadpole tails, which only subsequently become nucleated. On this point, however, further investigations are needed. In the mean time we may admit that the wandering cells also serve for the formation of young connective tissue. We have been so strongly predisposed in favour of the formation of tissue from cells ever since Lehmann first taught that newly formed tissue always results from young cells, that the idea of an independent growth of a finished structure without the aid of cells finds but little favour; the formation of cells also by means of budding out, with subsequent development of a nucleus in the bud is a process, which histologists have long kept in the background and everywhere substituted for it cell subdivision; botanists, on the contrary, in the development of vegetable tissue, attribute a most important *rôle* to this mode of tissue formation. It will be seen from the most recent observations, already referred to, that the walls of the capillaries, the axis-cylinder of nerves, the contents of muscular fibres, really do possess the power of growing out without the direct participation of new cells. Rokitansky has already claimed for the connective tissues the power of independent growth. Seeing the earnest and constant research which is being made in this direction, it will probably not be very long before we arrive at a proper conclusion concerning this point.

In man, the regeneration of nerves takes place only within certain limits, which, it is true, cannot be very exactly defined. The complete regeneration of large nerve-trunks, such as the sciatic or median, does not take place, nor after excision of portions of a nerve-trunk if the extremities of the nerve be separated to the extent of about one centimètre (half an inch). A very accurate

apposition of the ends of the nerve is absolutely necessary for their union, since the transformation of the newly formed intermediary substance into nerve substance can certainly only take place through the agency of the nerve-extremities, although there may be differences of opinion as to the nature of this process. We shall presently find that similar conditions obtain in the healing of broken bones; for bony union only results where there is a proper coaptation of the fragments. Now, what is the condition of things in this respect in the tissue of the brain and spinal cord? In man there is no regeneration after injury or loss of substance in consequence of spontaneous inflammation, or at least not sufficient to re-establish function. It is true that, in animals, as Brown-Séquard has demonstrated in pigeons, regeneration with recovery from the paralysis which naturally affected all parts below the seat of injury, may follow complete section through the spinal cord. Unfortunately this power of repair in nerves decreases in direct ratio with the higher development of vertebrates, and in man is least marked of all. In young salamanders it is well known that whole extremities grow again after having been amputated. It is a pity that this is not the case with man! Nature, nevertheless, occasionally makes a fruitless attempt at regeneration as regards the nerves. It often happens that the nerve-extremities in a stump, instead of simply cicatrising, develop into club-shaped expansions. These nodules (amputation neuromata) consist of primitive nerve-fibrils all tangled together, which seem to have developed from the nerve-stump as though they were growing towards similar fibres coming from an opposite direction. Cicatrices in the continuity of a nerve sometimes remain knotty, owing to the formation within them of superabundant fibrils which become twisted on themselves. Such like small nerve tumours (true neuromata) are sometimes exceedingly painful, and have to be removed with the knife. There are also traumatic neuromata which are never painful, as I have seen in old amputation stumps. These proliferations of nerve scars are generally compared with hypertrophy of ordinary cicatrices and with growing masses of bone, which, although rarely, are sometimes found in great superabundance in the healing of fractures.

The process of healing in the great vessels after injury, especially of arterial trunks, has been carefully and experimentally investigated. When a large artery is ligatured, whether after amputation or on account of injury or disease in its continuity, the tunica intima is

ruptured when the ligature is drawn tight and the tunica muscularis and the adventitia are pressed together, so that their interior surfaces become accurately apposed. It is easy to satisfy yourselves of the frequent, though by no means constant, rupture of the tunica intima by the feeling of gentle crackling or grating which, not seldom, is appreciable to the fingers while in the act of ligaturing large vessels; you may verify this too on the dead subject by removing the ligature and opening up the artery.

Fig. 29.

Club-like extremities of nerves in an old amputation stump of the arm. From a preparation in the Museum at Bonn. Copied from Froriep, 'Surgical Plates,' vol. i, pl. 113.

It is generally believed that the artery becomes plugged with coagulated blood, a so-called thrombus (ὁ θρόμβος, a clot of blood) from the point of ligature to the next branch, which is given off both at the central and at the peripheral extremity. The ligature destroys the enclosed tissue, which gradually softens, and when this process is complete the ligature drops off, or, as we technically express it, "the ligature cuts through" or "comes away." When this takes place the arterial lumen must of course be permanently and securely closed, or otherwise hæmorrhage would immediately occur. Under unfavorable conditions it sometimes happens

both in small, in middle-sized and in large arteries that the ligature comes away too soon, and then very dangerous and sudden secondary hæmorrhage occurs. This may be expected if the arterial walls are diseased; it is often quite impossible to ligature calcified arteries, because the ligature either does not occlude the lumen of the vessels or cuts its way through almost immediately. There are also conditions of softening of arteries (as, for instance, when portions of them have been for a long time exposed in an abscess cavity) in which a ligature would probably cut through while in the act of tightening it; in such cases it is of course desirable to apply the ligature at some spot further removed. Unfortunately hæmorrhage may occur at the seat of ligature only too often, even in healthy men, as I had reason to experience during the late war; this is because ligatures, even when applied according to all rules of the art, sometimes cut their way out through the arteries too quickly, and before the organic plug has become sufficiently solid to successfully withstand the pressure of the oncoming blood wave, an unfortunate circumstance that considerably lessens the value of an operation, which is often absolutely essential to life.

Let us now take into consideration what takes place in the end of the vessels from the period of coagulation of the blood until when the closure is complete; experiments on animals and accidental observations in man have taught us the following facts. The blood-clot, which at first lies loose in the vessel, gradually attaches itself more and more firmly to the wall of the vessel, and at the same time becomes more compact; it, however, remains red for a long time. It is only after weeks or months that it becomes decolorised, and then in the centre first, so that the remainder still retains a light yellowish colour. After the removal of the ligature the thrombus is so hard, and adheres so firmly to the vessel-wall, that its lumen becomes completely closed. This preparation (fig. 30) shows the formation of a thrombus in an artery after ligature in its continuity; the lower one reaches as far as the origin of the next branch, the upper one not quite so far. The former condition should, according to most books, be the rule,

FIG. 30.

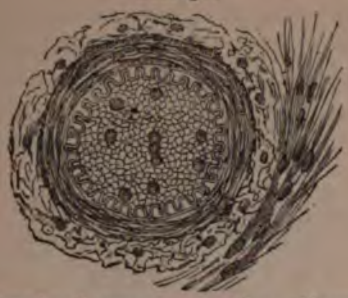
An artery ligatured in its continuity. Thrombus. After Froriep.

the latter the exception; but according to my own experience in the ligature of large arteries, this condition very frequently occurs. The plugging of a vessel by means of a solidifying blood-clot is, however, only a temporary condition, because the thrombus does not remain as such for any length of time; it becomes converted into cicatricial tissue and atrophies: this takes place in the course of months or years, during which time the closure of the artery has become complete at the divided spots by the blending together of its walls. If you examine such an artery some months after its ligature you will see nothing of the clot, but will find that the artery terminates in a conical point among the connective tissue of the cicatrix.

The changes which we have just sketched can be followed with the naked eye; they show that the changes which take place in the blood-clot essentially consist in its solidification and in its increasing adhesion to the wall of the vessel. Let us now study these changes microscopically. If you examine the recent blood-clot, you find it to consist of red corpuscles, a few colourless corpuscles, and of a fine irregularly arranged fibrillated network, the coagulated fibrine. Take a thrombus from a small or medium-sized artery, two days after ligature you will find it harder than before and more difficult to break up; the red corpuscles are little altered, the white ones are considerably increased (in number); some show two and three nuclei, as usual, others single, pale oval nuclei with nucleoli; some of these cells are twice the size of a white blood-corpuscle. The fine fibrils of the fibrine are bound up into a firm, almost homogeneous mass. If you further examine a six days' old thrombus, the red blood-corpuscles have almost disappeared; the fibrine is, if possible, firmer and more homogeneous, and still more difficult to tear; a large number of spindle cells with oval nuclei are visible. From what has been said, it is evident, then, that a number of formative cells early appear in the blood-clot, the further development of which will be given further on. As a more exact idea of the changes in the thrombus, and of its relation to the arterial wall can be obtained by making transverse sections of thrombosed arteries, let us make use of such for our further studies. The annexed diagram (fig. 31) represents a transverse section of a recent thrombus in a small artery. The delicate central mosaic work is formed by the compressed red blood corpuscles, among which are a few round white blood-cells (which have been rendered visible by staining with

carmine); then comes the tunica intima, which is arranged in regular folds, within which the blood-clot becomes firmly adherent; then the

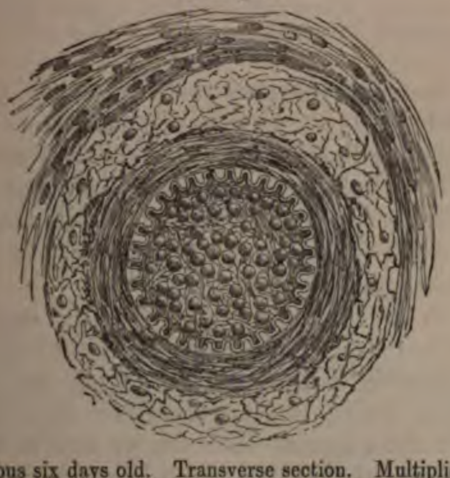
FIG. 31.



Recent thrombus in transverse section. Magnified 300.

tunica muscularis, and lastly the tunica adventitia with a network of elastic fibres, to which on the right side a little loose connective tissue is attached.

FIG. 32.

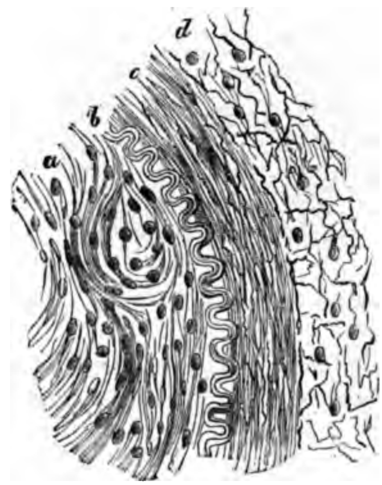


Thrombus six days old. Transverse section. Multiplied 300.

This preparation (fig. 32) is the transverse section of a thrombosed artery of the sixth day, from the human subject. Here nothing more can be seen of the red blood-corpuscles, but in their place is an exceedingly fine network of fibrils; the white cells are much increased

in numbers, and mostly round, while in the tunica adventitia and the surrounding connective tissue the infiltration of cells has already taken place.

FIG. 33.



Thrombus of ten days; *a*, organized thrombus; *b*, tunica intima; *c*, tunica muscularis; *d*, tunica adventitia. Magnified 300.

If we now examine a thrombus ten days old (fig. 33) in a large muscular branch of the thigh (after amputation), we shall find a number of spindle cells, some of which will be arranged in loops, which subsequently become vessels; the intercellular substance is markedly fibrillated and rendered transparent by acetic acid. Finally blood-vessels are formed in the thrombus, as may be seen in the following preparations (figs. 34 and 35).

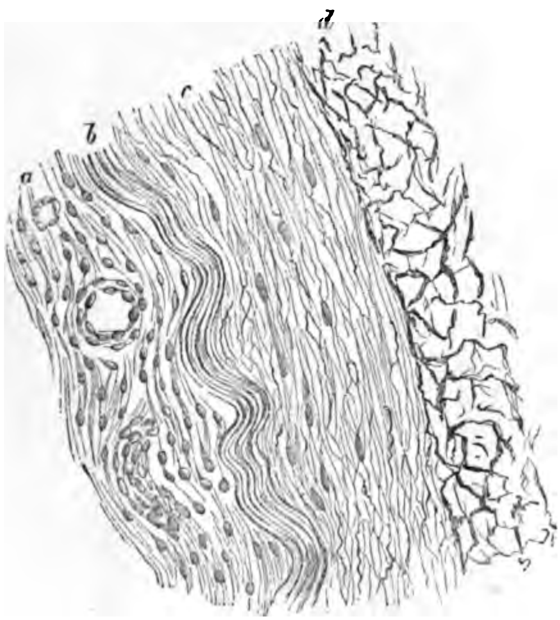
According to the researches of O. Weber it is established that the vessels of the thrombus anastomose partly with the thrombosed vessel itself and partly with its vasa vasorum (fig. 35).

The process of healing in veins which have been divided transversely at first sight appears much simpler than in the arteries; even the large veins of the extremities collapse when cut across and appear to heal up without further trouble, when the blood has been arrested at the next valve above; about these valves a coagulum forms, often more extensively than we desire. Blood-clots extending in the direction of the heart will occupy our earnest attention a little later on.

I have more recently observed, however, that the intima of a divided vein does not by any means always simply collapse and become adherent; but that a small thin clot is formed, which becomes organized just in the same manner as arterial thrombus.

If we may draw any conclusions from the few preparations which I have here demonstrated, it results that a cell infiltration takes place into the coagulated blood-clot, which leads on to the development of connective tissue; in short, the thrombus becomes organized. The thrombus however is not a permanent structure; it

FIG. 34.



Completely organized thrombus in the posterior tibial artery of man; *a*, thrombus with vessels blended with the innermost layer of the intima; *b*, lamellæ of the tunica intima; *c*, tunica muscularis traversed by a number of connective tissue and elastic fibres; *d*, tunica adventitia. Magnified 300. After Rindfleisch.

disappears gradually, or rather is reduced to a minimum, a state it shares with many other new formations, the results of inflammation.

There are special reasons which induce me to investigate a little

more thoroughly the organization of thrombus. The importance of this process is very extensive, and one which you can hardly appreciate at present; but later on, when we come to consider diseases of vessels, and new growths generally, you will then be better able to appreciate it fully.

I do not think as the result of my investigations up to the present time, that I am in a position to withdraw the statement, that coagulated fibrine *may* be converted into an intercellular

Fig. 35.

Longitudinal section of the ligatured extremity of the femoral artery of a dog fifty days after the operation. Thrombus injected; *a a*, tunica intima and media; *b b*, tunica adventitia. Magnified 40. After O. Weber.

connective tissue by the aid of cells, although I must needs leave it undecided, whether it be the result of a true metamorphosis, or of a gradual substitution of nucleated protoplasm for the shrinking fibrine. The attempt has often been made to attribute the origin of the constantly increasing number of cells in the thrombus to

the arterial wall; the arteries, like the veins, are lined by an internal epithelial coat, which to some extent represents the innermost layer of the tunica intima. These epithelial cells, and also the nuclei of the striped lamellæ of the intima have been claimed by some authors as the natural source of the new cells; which thence grow into the thrombus. Thiersch has

FIG. 36.

Portion of transverse section of the femoral vein of man, with an organised vascular thrombus, eighteen days after amputation of the thigh; *a a*, tunica intima; *b b*, media; *c c*, adventitia; *d d*, surrounding connective tissue; *Th*, organized thrombus with vessels; the layers of fibrine in the peripheral portions of the thrombus are still distinctly appreciable. Magnified 100.

accepted this view in his most recent work. I must admit, that formerly I was much opposed to the acceptance of this doctrine, that the blood could organize out of itself connective tissue with blood-vessels; but now, as the result of the study of transverse sections of thrombosed arteries I am inclined to accept the view.

[illegible] inflammation has [illegible] the proliferating [illegible] then, whence come the [illegible] white blood- [illegible] wandered [illegible] Recklinghausen and [illegible] it appears that they [illegible] their form, and then [illegible] connective tissue [illegible] whence do these white cells get [illegible] and that they are formed [illegible] connective tissue [illegible] cells, which originate directly from connective tissue or from masses of protoplasm related to connective tissue. Now are these cells, when enclosed in a blood-clot, [illegible] when arrested here, convert themselves into [illegible]? It is for the present quite impossible either to affirm or deny this point accurately. Since Bubnoff has shown that wandering cells penetrate into a thrombus and may continue to [illegible], it is no longer possible to argue that the white blood-cells (with which the wandering cells are identical) contained in the original thrombus, cannot also move about, and become converted into tissue. But whether wandering cells can penetrate the arterial walls as easily as the walls of veins must for a time remain undecided, for Bubnoff's experiments only relate to venous thrombi. Some of my investigations on this subject have convinced me that fine granules of cinnabar do pass through the walls of the carotid artery (for instance) of a dog, into the thrombus, but I have not been able to convince myself that these granules were conveyed by the wandering cells. For the present therefore it remains undecided where the numerous wandering cells in an organizing blood-clot originate, and how they arrive there. [illegible], in a recently published work, has drawn attention to the fact that a large proportion of the larger thrombi disintegrate, which is quite true; he however goes too far in denying the provisional organization of the thrombus, and in attributing directly to the disintegration of the coagulum the adhesion of the walls of the vessel, a result which, as the termination of the whole process, I

have all the while had in view. Some recent investigations on the formation of vessels by Arnold, as also some observations on tubercle to which we shall hereafter refer, furnish us with new material in support of the view, that the wall of the vessel itself and its lining endothelium are chiefly concerned in this tissue formation; and in a still more recent work, Riedel has almost conclusively shown that the greater part of the young tissue which is formed in the thrombus, proceeds from the endothelium. Thus the views on this point have vacillated for years past.

As already remarked, peculiarly favorable conditions of nutrition are necessary for the blood-clot to become organized. It is an absolute law in the human organism, that non-vascular tissues, which are nourished by cell-product alone, have no great extent; look at the articular cartilages, the cornea, the tunica intima of the vessels, all these tissues consist of thin layers: in other words, the cells of the human body, unlike vegetable cells, are unable to carry the nutritive fluids to an unlimited distance; they can convey them only in a limited manner, and at certain distances new vessels must be formed in order to convey and carry off these fluids. A blood-clot consisting of cells and coagulated fibrine, is at first a non-vascular cell-structure, which can only maintain its existence when in thin layers. This will be gathered from observations to which we shall frequently have occasion to refer; namely, that large clots either are not organised at all, or only organised in their peripheral layers, while the central parts disintegrate. It is manifest therefore that in healing by the first intention a thin layer of blood between the edges of the wound does no harm, but that a larger quantity of blood interferes with healing, and possibly prevents it altogether, a fact which you can often enough verify in the wards.

The doctrine of the formation and organization of thrombus has seriously occupied surgeons and anatomists since John Hunter, and even now is not by any means to be regarded as settled. We have had to discuss this doctrine here, if only on account of its general histiogenetic interest, though in recent times it has become very doubtful, whether it has such an important bearing on the results of ligature, as has hitherto been ascribed to it. Porta some time ago pointed out that the early closing up and healing of the tissue surrounding an artery were as important as the organization of the thrombus itself. Surgeons too have always kept this point in view, and have insisted on the necessity of trying to secure healing by the

first intention by a careful operation and by careful after treatment. It has now become quite evident through the extensive practical results of acupressure, that the infiltration of the tissues by the coagulation of organizable lymph even after forty-eight hours suffices to hold the compressed or twisted ends of the arteries quite firmly, even such arteries as the femoral; though Kocher has shown that the thrombus in an artery after acupressure is not absent, yet it is often so small that it could not possibly withstand the force of the blood current in a large artery forty-eight hours after closure.

Let us now turn our attention to the condition of the circulation after ligature of one of the larger arteries in its continuity. Suppose, on account of hæmorrhage in the leg, that we have had to tie the femoral artery; how does arterial blood get into this leg? how will the circulation be re-established? In the same way as after

FIG. 37.

FIG. 38.

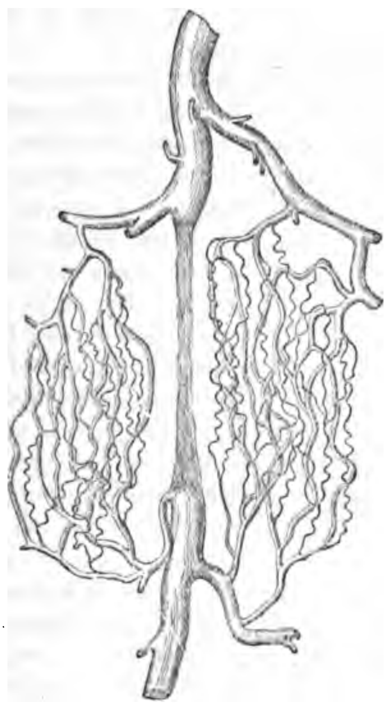
FIG. 37.—Carotid artery of a rabbit injected six weeks after ligature. After Porta.

FIG. 38.—Carotid artery of a goat injected thirty-five months after ligature. After Porta.

closure of certain capillary districts, the blood, in consequence of increased pressure, presses through the nearest open vessels, and these in consequence dilate; and so too after closure of the

smaller and medium sized arteries. The blood, under increased pressure, streams through the branches next above the thrombus, and thanks to the free anastomosis both in the long and transverse axes of the limb, it thus reaches other arteries, through which it quickly arrives at the peripheral extremity of the ligatured vessel. An arterial collateral circulation is, in fact, established through the branches of the ligatured artery. Without such an occurrence,

FIG. 39.



Femoral artery of a large dog injected three months after ligature. After Porta.

the part of the body below this point would not receive any more blood and would die; it would either dry up or slough. The arterial anastomoses are fortunately so plentiful, that even after ligature of large trunks, such as the axillary or femoral, this condition seldom happens; with diseased arteries, nevertheless, which do not readily dilate, gangrene of the corresponding limb may occur after ligature of the main vessels. The way in which these new arterial anasto-

moses form varies greatly. Years ago Porta instituted some very important investigations on this point, and as the results of his numerous experiments gave the following as the chief types of collateral circulation:

(1). Direct collateral circulation, that is, some well-developed vessels spring up which convey the blood directly from the central to the peripheral extremity of the artery.

These connecting vessels are, for the most part, dilated vasa vasorum and the vessels of the thrombus; it might even happen that one of these connecting vessels might so dilate as to appear like the main trunk regenerated.

(2). Indirect collateral circulation, that is, the anastomoses between the next largest branches of the main vessel become much developed, as in the case from which this drawing was taken (fig. 39).

The most typical examples of these two varieties of collateral circulation have of course been chosen; for if you examine the numerous drawings in Porta's book, or if you repeat an experiment for yourselves, you will find that these two varieties are generally combined; the division possesses, therefore, no other worth than that of convenience. It is an excellent anatomical exercise to picture to yourselves how, after ligature of the different arterial trunks of one or other of the extremities of the trunk, the blood arrives at the parts beyond the ligature; you will find the plates of arterial anastomosis in Krause's 'Handbook of Anatomy' of great service to you. These anatomical relations are also thoroughly exhausted in Conrad Martin Langenbeck's work on 'Surgery' in the chapter on aneurism. The reversed blood current, which not unfrequently takes place in these collateral circulations, occurs with marvellous rapidity if the anastomoses are free; thus, if the common carotid artery in a man be ligatured and the artery be divided peripherally, the blood will stream out of the peripheral extremity with immense force, that is backwards, as if from a vein. In all such cases, when an anastomosis of an artery which has to be ligatured is free, we must apply a ligature both to the central and to the peripheral end if a portion of the artery has to be cut out, or otherwise we shall certainly get hæmorrhage. This is an important rule, and one which is often neglected in practice.

LECTURE X.

CHAPTER II.

ON SOME PECULIARITIES OF PUNCTURED WOUNDS.

Punctured wounds, as a rule, heal quickly per priman. Needle pricks; needles remaining in the body, their extraction. Punctured wounds of nerves. Punctured wounds of arteries. Aneurism, traumatic, varicose, aneurismal varix. Punctured wounds of veins. Bleeding.

Most punctured wounds are simple wounds, and heal, as a rule, by the first intention; many of them are at the same time incised wounds if the instrument have a certain breadth; many resemble contused wounds if the instrument with which they are inflicted is blunt, in which case there is more or less suppuration. We constantly make punctured wounds with our surgical instruments, as with acupuncture needles, fine long needles which we occasionally use for the purpose of examining whether, and how deeply the bone is involved beneath a tumour or an ulcer; also with acupressure needles, which we employ for the purpose of arresting hæmorrhage; with the trocar also, a three-edged sharp dagger, which is surrounded with a closely fitting canula; we use this instrument for the purpose of drawing off fluids from various cavities. Dagger, sword, knife, and bayonet wounds are often to be regarded both as punctured and incised wounds, or punctured and contused wounds. If these wounds are uncomplicated with injury of the larger arteries or veins, or with injury to the bones, or if they do not penetrate into any of the great cavities, they seldom require any special treatment.

The commonest punctured wounds are those made by needles; they occur for the most part in women, and how seldom is a doctor

required! Such an injury only becomes complicated when the needle or a broken-off portion of it penetrates deeply into the soft parts, and cannot be readily extracted. This may happen in different parts of the body, as when a person accidentally sits down on a needle, or falls on one, or in some other accidental way. If a needle has penetrated deeply under the skin the symptoms are usually so slight that the patients seldom experience any pain from it, in fact, are often quite unable to tell whether the needle has really entered, or to say where it is situated. These bodies seldom produce any external evidence of inflammation in the soft parts, but many remain in the body for months, years, or even throughout the whole life without giving rise to any unpleasant consequences, provided they do not enter a nerve trunk. A needle seldom remains stationary at the spot where it enters, but wanders about, that is, it is driven about to other parts of the body by muscular contraction; it may thus travel for some distance through the body, and turn up again in quite another region. Examples of this have been observed where hysterical women, for the purpose of attracting the attention of medical men, have intentionally thrust needles in large numbers into different parts of the body; these needles made their appearance first in one place, then in another. Even needles that have been swallowed may pass without danger through the walls of the stomach or intestines, and come to light at any part of the abdominal wall. B. v. Lagenbeck once found a pin in the centre of a vesical calculus; on close inquiry, it was discovered that the patient had swallowed it when a child. The pin must have passed through the intestine into the bladder, where the triple phosphates were deposited on it in layers, and so gave rise to the calculus. Dittel has observed a similar case.

If needles have remained in the soft parts for a considerable time without giving rise to pain, or if needles, which are wandering from within outwards, come to the surface and close beneath the skin, they often give rise to a little suppuration, and the sensation of pricking becomes more definite; you must then make an incision into the painful place; a little thin pus will be found in the abscess cavity, together with the needle, which may easily be extracted with the forceps. Why these bodies, which for months may be driven about in different parts of the body should give rise to suppuration, when they at length arrive beneath the skin, is quite incomprehensible. You must, however, for the present be satisfied

with the fact that it is so. The following interesting case may help to make the course of such an injury a little more intelligible. An idiotic deaf and dumb female, about thirty years of age, was brought into the Zurich Hospital with the diagnosis "typhoid." We could obtain nothing further of the history either from the woman herself, nor from her friends, who themselves were not over bright. The patient, who would often remain in bed for days together, had complained for some days past of pain, which she referred to the right ileo-cœcal region; she was rather feverish too. On examination, a swelling was found at this spot, which increased in size during the next few days; it was painful on pressure; the skin became red and fluctuation distinctly evident. It was easy to recognize that this was not a case of typhoid, but you may imagine what a variety of diagnoses was made as to the seat of the suppuration, for an abscess quickly formed; it might have been an inflammation of the ovary, a perforation of the vermiform appendix or an abscess in the abdominal wall, &c., though there was something to say against each one of these views. In the course of a few days the inflamed skin became very thin; the abscess concentrated itself close to the anterior superior spine of the ilium, one finger's breadth above Poupart's ligament. I now made an incision into the skin, and let out a quantity of fæcal-smelling, brown coloured, decomposing pus; while examining the abscess cavity with the finger, I perceived deep down in it, a hard, rodlike, solid body, which, however, was but slightly prominent. I commenced to extract it with a pair of forceps, and pulled and pulled until I had extracted a medium-sized knitting needle, almost a foot long; it was somewhat rusty and seemed to point towards the pelvis. The abscess cavity was covered with granulations; I endeavoured to find the sinus which the needle must undoubtedly have left behind, but failed to do so; it must have closed almost immediately, and was lost in the granulations.

The abscess required a long time to heal; it did, however, finally close without any ill results, and the patient was discharged in about a month. When I showed the unfortunate cretin the needle she only laughed in her idiotic repulsive manner. This was all we could learn about it; it may possibly have stirred up some faint recollection of the needle in her mind.

It is most probable that the patient had inserted the needle either into the vagina or rectum, a kind of procedure to which, unfor-

tunately, women, who are not idiots, are incredibly prone, as you may read in Dieffenbach's 'Operative Surgery' in the chapter on the extraction of foreign bodies. It is not impossible that the needle in this case passed up near the portio vaginalis uteri into the cæcum, and from the fact that the pus contained air, we may fairly argue that there had been a communication, if even only a temporary one, with the gut. This cannot be regarded as at all sure, seeing that pus, when in proximity with the intestines may decompose and give rise to stinking gases, even when there is no communication with the intestine past or present.

The extraction of recently penetrated needles may often be very difficult, as patients are not seldom quite uncertain as to their position, and often, from shame, will not acknowledge how the needles got in (into the bladder for instance). Before an incision is made into the skin, the spot at which the foreign body is believed to be felt, must be fixed with the left hand; this is absolutely necessary, lest the needle should change its position during the incision. Occasionally the foreign body may be felt more or less distinctly, and pressure on it causes sharp pain: such and similar manipulation must guide us in our incisions. After the skin has been incised, we must endeavour to seize the needle with a good pair of dissecting forceps: tense bands of fascia, especially about the fingers, may easily deceive us, for with forceps our sense of touch is always uncertain. If the needle cannot be found, we may let the parts be moved about somewhat; this may get the needle into a position in which it will be easier to seize hold of. The extraction of foreign bodies, which is very much facilitated by the use of Esmarch's bandage, requires a certain amount of practice and of manual dexterity, which is only acquired with time: an innate mechanical talent is extremely valuable in this matter. Besides needles, fine pieces of glass occasionally heal up in a wound. A short time ago I extracted a blackthorn, seven lines in length, which had lain for eleven years immediately beneath the skin of the leg without causing any marked pain.

Punctured wounds, made with instruments which are not very sharp, are occasionally interrupted in this process of healing: the external wound heals by the first intention, but after a few days inflammation and suppuration set in in the deeper parts, and the wound either opens again and the whole tract suppurates, or the pus breaks out at some other point. This subsequent conversion of

a simple puncture into a deep wound is especially apt to occur if a foreign body, as for instance, the point of a knife, remains behind, or when the injury is inflicted with a blunt instrument. You must always bear in mind the possibility of such foreign bodies being left behind, when you examine these wounds; endeavour, if possible, to see the instrument with which the wound was caused; inquire particularly too as to the direction which the instrument took, in order that you may the better know what parts have been injured. Often in unfavorable cases there is remarkably little inflammation or suppuration of the track of the wound. Thus a short time ago, a man presented himself at the Clinic, who the day before had fallen on to his arm from only a moderate height from a tree while engaged in lopping off the smaller branches. The left arm for some inches below the elbow was swollen on its dorsal surface; on its inner surface, just above the wrist, a small excoriation was visible; the arm could be flexed and extended without pain, but pronation and supination were interfered with and painful. There was no fracture of the bones of the forearm; the bones were certainly not broken completely, but at the seat of the swelling on the dorsal surface of the limb, two centimetres (a little less than one inch) below the elbow, I could distinctly feel, immediately beneath the skin, a solid body, which could be depressed, but which immediately sprang up again into its former place. It gave one the impression that a piece of bone had been partially detached and lay close below the skin. However incomprehensible it might seem, that such a piece of bone could be detached without a solution of continuity of either radius or ulna from a simple fall on to the ground, I nevertheless ordered the patient to be chloroformed, and renewed the attempt to reduce the projecting portion of bone. I did not however succeed. As it lay so close to the surface, and must infallibly have come through the skin within a very short time, I cut down on to it, in order to extract it. To the astonishment of us all, I drew out, not a fragment of bone, but a small twig of the tree, five inches long, which had been very firmly held between the two bones of the forearm. It was at first difficult to explain how this bit of a branch had got into the arm, though on a closer examination of the before-mentioned excoriation on the inner surface of the arm, it was found to be an incised wound, which had almost closed. The foreign body must have penetrated so quickly that the patient did not perceive it. After the extraction the swelling entirely disap-

peared, there was but little discharge from the wound, and in eight days it was completely healed.

These favorable results as regards the healing of punctured wounds have led to what we now call subcutaneous operations; they were first introduced into surgery by Stromeyer and Dieffenbach, and consist in introducing a narrow pointed knife under the skin, and dividing, for different purposes, tendons, muscles, or nerves, without making any further wound than the simple puncture, through which the tenotome (tendon-knife) is introduced. The healing process under these circumstances is rapid and almost always takes place by the first intention, while with the open treatment there is nearly always suppuration and not seldom extensive necrosis of the tendon beside. We shall have to speak further of this matter in the chapter on deformities (see Chap. XVIII). It was formerly said that the absence of the irritating influences of the external atmosphere accounted for this rapid healing of such subcutaneous wounds.

After the correctness of this argument had been extensively questioned, it was next said that healing took place promptly because no cocco-bacteria germs could get into such wounds. This view too has found little acceptance. For the present, then, let us be satisfied with the bare fact.

If the puncture has penetrated one of the large cavities of the body and caused injury here, the prognosis must always be doubtful, and must be given guardedly, according to the physiological importance, and the greater or less liability to dangerous inflammation of the affected organs. As a rule, a punctured wound of this kind is not as dangerous as a gunshot wound. We will not further pursue this subject, but will pass on to consider punctured wounds of the nerves and vessels of the extremities.

Punctured wounds of nerves produce paralysis of variable extent, according to the extent of the wound. Regeneration naturally occurs more readily when the whole width of the nerve has not been divided. A totally different effect however is produced when a foreign body, such as the point of a needle, or a small bit of glass, is left behind in a nerve trunk, where, as in other tissues, it may heal in. The nerve cicatrix which holds this foreign body may remain exceedingly painful on the least touch, not unfrequently there are severe pains running excentrically; neuralgia may be set up; nay more, the most severe forms of nervous disease, both acute and chronic, may be developed. Epileptiform seizures with an aura,

that is, a preliminary pain in the scar which ushers in the attack, have been observed as the result of such injuries. Some surgeons believe also, that tetanus may be produced by such nerve irritation, but this appears to me to be very doubtful: of this anon. The extraction of the foreign body generally suffices to cure the first variety, which is classed as a reflex epilepsy. Punctured wounds of the larger arterial trunks or of their larger branches may bring about various results. A very small puncture closes almost immediately through the elasticity and contractility of the arterial coats: there is not always even bleeding, any more than there is always an escape of fæces from a minute puncture of the intestine. If the wound be slit-like, the bleeding would probably be insignificant, provided the wound do not gape very much. In other cases, however, severe hæmorrhage is the immediate result. If compression be at once applied and a suitable bandage carefully put on, one generally succeeds, not only in arresting the hæmorrhage, but also in getting the wound of the artery as well as that of the soft parts to firmly close. If the bleeding cannot be arrested, as already pointed out, we must immediately proceed to ligature the artery either by enlarging the wound above and below the seat of injury, or at some higher place in its continuity. The closure of an arterial wound takes place in the following manner:—A blood-clot forms in the more or less gaping wound of the arterial wall; this clot projects slightly into the lumen of the vessel, but externally it is larger, and covers the vessel somewhat like a mushroom. This clot becomes organized into connective tissue, in the same way as was described in intra-vascular thrombus, and so a permanent organic closure of the opening takes place without any narrowing of the lumen. This normal course of things may be complicated by the little plug which projects into the interior of the artery, giving rise to a deposit of fibrine from the circulating blood, and in this way to closure of the artery by clot-formation—arterial thrombosis in fact—but this is very rare. If it should take place, the same result would happen as after ligature; there would be development of collateral circulation, and eventually obliteration of the vessel by organization of the entire thrombus.

Punctured wounds of arteries do not always follow such a favorable course. In many cases a swelling is remarked shortly after the accident at the seat of injury, which gradually increases in size, and which is both seen and felt to pulsate synchronously with

the heart's systole. If we place a stethoscope over the swelling, we hear a distinct blowing and whirring sound. If we compress the main artery of the limb above the tumour, the pulsation and whirring sound immediately cease and the tumour decreases some-

FIG. 40.

Artery wounded at its side, with clot; 4 days after the injury. After Porta.

what in size. We call such a tumour an aneurism (ἀνευρύνω—to dilate), and this particular form, the result of accident, a false aneurism, in contradistinction to a true aneurism, which arises spontaneously as the result of various kinds of arterial disease.

How does this swelling form and what is it? Its origin is as follows: the external wound is closed by pressure, so that blood can no longer escape by it; but it nevertheless escapes from the artery, which is not yet firmly closed by the clot, into the soft parts around, and continues to burrow among these so long as the blood pressure is stronger than the resistance which the tissues oppose to its spread. In this way, a cavity filled with blood is formed in direct communication with the artery. Some inflammation is set up in the tissues around the blood, which coagulates in part; this plastic infiltration leads on to the formation of connective tissue, which forms a sac, into the interior of which the blood streams in and out, while the peripheral portions become filled with layers of coagulated blood-clot. The bruits which we hear in them are produced partly by the flow of the blood through the narrow opening, partly by its friction against the blood-clots, and partly by its regurgitation back again into the artery.

Such a traumatic aneurism may occur secondarily, that is, the arterial wound may heal at first, but on removal of the bandage the young cicatrix may give way and the blood will then stream out.

It is not always from punctured wounds that traumatic aneurisms arise. They may be caused by rupture of the arterial coats either by traction or bruising without any external wound. A. Cooper relates the following interesting case in his 'Lectures on Surgery:' A gentleman when out shooting was jumping over a ditch, and while doing so experienced a severe pain in the ham, which at once prevented his walking. An aneurism quickly formed in the popli-

teal space which had to be operated on. The artery was partially torn in the act of jumping. It suffices for the production of an aneurism that the tunica intima and muscularis be torn through. If the tunica adventitia remain uninjured the blood-stream may separate it from the tunica media, and in this way what we call a dissecting aneurism is the result. Cases of punctured wounds with

Fig. 41.

Traumatic aneurism of the brachial artery. After Froriep. Surgical plates, vol. iv, pl. 483.

subsequent aneurism occur especially in military practice, but not unfrequently also in civil practice. I recently saw a boy with an aneurism of the femoral artery as large as a hen's egg; it was situated at about the middle of the thigh, and had resulted from a wound with a penknife on to which the boy had fallen. I operated

the other day on an aneurism of the radial artery which had developed in a shoemaker as the result of a prick by an awl.

An aneurism is a tumour which communicates either directly or indirectly with the orifice of an artery. Such is the usual definition. The communication is direct in the case just described of simple traumatic aneurism. But, nevertheless, the anatomical conditions of this tumour may be much more complicated.

For instance, in venesection at the bend of the arm (that is, intentionally opening a vein in order to abstract blood), the brachial artery may be wounded. This is one of the most frequent causes of traumatic aneurism, or rather used to be when bleeding was more common. In such a case, besides dark venous blood, a bright red stream would be immediately recognised; the whole arm should be bound up and the artery compressed. In most cases both openings will heal up without any evil consequences. But it occasionally happens that an aneurism subsequently forms. This may be of the simple form just described, or the openings of the two vessels may so grow together that the arterial blood flows directly into the vein as into an arterial branch, and it then meets the stream of the venous blood.

FIG. 42.

Aneurismal varix; *a*, brachial artery. After Bell. Froriep's surgical plates, vol. iii, pl. 263.

This causes obstruction to the venous current, and gives rise to sacculations and to dilatations of the veins which we generally term varices; in this especial instance the varix is spoken of as aneuris-

mal, because, like an aneurism, it communicates with an artery. Another condition may also occur, namely, the formation of an aneurism between the artery and the vein, that is, both artery and vein communicating with the aneurismal sac.

Fig. 43.

Varicose aneurism; *a*, brachial artery; *b*, median vein. The aneurismal sac is slit open. After Dorsey. Froriep's surgical plates, vol. iii, pl. 263.

We call this condition varicose aneurism. There may be numerous varieties in the relations of the aneurismal sac and of the vein and artery to each other, but these are only interesting as curiosities; they neither alter the symptoms nor the treatment, and fortunately have no special names given to them. In most cases, in which arterial blood flows directly or indirectly through an aneurismal sac into veins, a dilatation takes place, and a thrill may both be felt and heard in them and which is occasionally perceptible also in the arteries. It is probably caused by the meeting of the two currents. The thrill, however, is not characteristic of varicose aneurism, since this condition can be produced simply by pressure on the veins; it is present too in many forms of heart disease. But if in addition to the thrill a slight pulsation can be felt in veins distended by the above cause, then we shall be more likely to arrive at a correct diagnosis.

Some little time back I had the opportunity of seeing several aneurisms which were the results of gunshot wounds; in three cases which affected the femoral artery and the external iliac the thrill was so strongly marked that injury to the artery and also to the vein, with communication between the two, was necessarily

diagnosed; in one case the post-mortem examination proved this to be correct. In none of these cases were there any varices; hence we must assume either that they are not necessarily formed as the result of a communication between artery and vein, or that they only result in the course of years.

Aneurisms of arteries, if they remain small, scarcely ever produce any great inconvenience. In the generality of cases, however, the aneurismal sacs become larger and larger; disturbances in the functions of the affected limb come on, and, finally, the aneurism may burst and lead to fatal hæmorrhage. Treatment must consist, in the majority of cases, of ligature of the arterial trunk, but of this later on. I have considered it desirable to explain to you in this place the development of traumatic aneurisms because they generally occur in practice as the result of punctured wounds; in surgical handbooks they are usually treated of under diseases of the arteries. Of spontaneous aneurisms and their treatment we shall speak in a separate chapter.

Punctured wounds of veins heal exactly like those of arteries, so that I need not add anything to what has already been said. Perhaps I may just remark that extensive clots form far more readily in veins than in arteries; thus, traumatic venous thrombosis is far more common after venesection than arterial thrombosis is after punctured wounds of the arterial walls, and what is far worse, the first form of thrombosis entails much more serious results than the latter. Of this you will hear more at a future time, perhaps more than you care for. We have already referred to venesection, a little surgical operation which was frequent enough formerly. We will briefly describe the method of performing the operation, although you will more quickly and more thoroughly understand it by once seeing it done than by any description I can give you of it. If I were to try and tell you under what circumstances venesection ought to be practised, I should have to enter very deeply into the science of medicine; a large book might be written on the subject of the indications, the contra-indications, the admissibility, the utility, and the evils of venesection. I prefer, therefore, to pass over this subject in silence, as over other things which you may learn from daily observation in the clinics in a few minutes; whereas without some special case for demonstration several hours would be required for its explanation. I will only just refer to the historical fact, that whereas in olden times venesection took place from any of the

subcutaneous veins, now-a-days the operation is almost always done at the bend of the elbow. When you wish to bleed, first apply a bandage to the arm sufficiently tight to cause obstruction in the peripheral veins; for this purpose a well-adjusted pocket handkerchief answers very well, or the scarlet bleeding bandage furnished with a buckle may be used.

If this bandage has been properly applied the veins of the arm begin to swell, and at the bend of the arm, the cephalic and basilic, and their corresponding median veins present themselves. You open whichever vein is most prominent. The arm is flexed to an obtuse angle, you fix the vein with the thumb of the left hand, then with a lancet or with a fine-pointed straight scalpel in the right hand, you plunge into the vein and make an incision about half a centimètre long (quarter of an inch). The blood streams out; you allow as much as is necessary to flow, and then occlude the wound with your thumb; next remove the bandage from the arm, and the bleeding will cease almost spontaneously; the wound must now be closed with pad and bandage, and the arm kept at rest for three or four days; by this time the wound will have healed. Easy as this operation is in the generality of cases, it, nevertheless, requires practice. Puncture with the lancet or scalpel is to be preferred to the phlebotome; this latter instrument was much used formerly, but is now very justly going out of use; the phlebotome is a fleam which is plunged into the vein by means of a spring; the instrument, in fact, is allowed to operate instead of being safely guided by the hand.

There are many mechanical obstacles which may interfere with venesection. In very fat people it is often difficult either to see or to feel the veins through the skin. We then make use of other means besides compression, for we order the forearm to be put into warm water; this causes a stronger afflux of blood to the part. The fat, even after opening the vein, may prevent the flow of blood by its little lobules covering over the opening. In such a case you must quickly cut them off with a pair of scissors. Occasionally a mechanical hindrance to the flow of blood is produced by the arm assuming a different position either through flexion or extension after the puncture, so that the opening into the vein no longer corresponds with that in the skin; this may be remedied by again altering the position of the arm. There are other causes also which interfere with the flow of blood; for instance, the opening may be too small, a frequent occurrence with beginners, or the compression

is too weak; this is to be remedied by tightening the bandage, or, on the contrary, the bandage may be too tight and the artery compressed so that little or no blood can get into the arm; this of course is to be remedied by loosening the bandage. A way of helping the flow is to cause the patient to open and shut the hand rhythmically, so that the blood may be forced on by the muscular contractions.

LECTURE XI.

CHAPTER III.

ON SIMPLE CONTUSIONS OF THE SOFT PARTS.

Causes of contusions.—Nervous shock.—Subcutaneous rupture of vessels.—Rupture of arteries.—Ecchymosis.—Absorption.—Termination in fibrinous swellings, in cysts, in suppuration, in sloughing.—Treatment.

THE skin may or may not be broken by the striking of a blunt body on the soft parts: thus we distinguish between contusions with and contusions without skin wounds. We will first consider these latter.

Contusions are caused either by the falling of heavy objects on to the body, or by their striking severely against it, or by the body falling or striking against hard solid substances. The immediate consequence of such a bruise is a crushing of the soft parts, which may be of the most variable degree of severity; in some cases we can hardly appreciate any change at all, in others the parts are bruised to a pulp.

Whether the skin suffers a solution of continuity from such a blow depends on various circumstances, *e.g.* the form of the object which inflicts the blow, the force with which it strikes, and the nature of the parts below the skin. For instance, the same force which would produce contusion of the muscles of the thigh without injuring the skin would cause a wound of the latter if applied over the crest of the tibia, because the sharp edge of the tibia would itself almost cut through the skin. The elasticity and the thickness of the skin have also to be taken into consideration; not only do they vary in different persons, but also in different parts of the same body; so that in a simple contusion we cannot directly recognise the amount of injury but only indirectly,

and this from the state of the nerves and vessels, and from the subsequent course of the case.

The first symptom of contusion of nerves is pain, as it is in wounds, but then the pain is duller and more indefinite, although it may be very severe. In many cases, especially after striking against a hard body, the patient feels a peculiar tingling, numbing sensation in the affected part; this feeling, which extends considerably beyond the seat of injury, is produced by the shock which the nerve substance has suffered. For instance, if we strike the hand or a finger rather severely, only a small portion is actually contused, and yet not unfrequently there is concussion of the nerves of the whole hand, with severe dull pain and tingling, on account of which the fingers cannot at first be moved: there is also almost complete loss of sensation. This condition quickly passes off—generally in a few seconds, and then we experience a peculiar burning pain in the contused part. We have no other explanation of this temporary condition except that the substance of the nerves, most probably the axis cylinder, undergoes some molecular change as the result of the concussion, which again spontaneously passes off. These symptoms of shock do not by any means accompany all cases of contusion; they are absent in most cases where a heavy body strikes a limb at rest. In contusions of the head, however, they are not unfrequently of great moment, for in these cases we have not only *commotio cerebri,* we get also *contusio cerebri;* or we may have simply the former, as the result, for instance, of a fall on to the feet, or on to the seat, whence the shock is conveyed to the brain, and the severest symptoms, even death may result, without any appreciable anatomical changes in this organ being discovered. Concussion is a process which we prefer to locate in the nervous system, and we speak of a cerebral and of a spinal concussion. Still the peripheral nerves may be shaken with the symptoms above given; but since the local injury is the more prominent, the nervous condition is perhaps too much overlooked. A severe concussion of the chest may give rise to the most serious symptoms through shock to the heart and lung nerves, whereby the circulation and respiration are for a longer or shorter period disturbed. Nor can we entirely deny the reflex action of a concussed nerve, especially of the sympathetic, on the brain. Doubtless some of you, when wrestling or boxing, have sometimes received a blow on the abdomen: what horrible pain! For the moment a feeling of

faintness comes over you; this is the effect on brain and heart; one has to hold one's breath and gather up one's strength in order not to fall outright. Concussion of the ulnar nerve frequently occurs from a blow on the elbow; the severe dull pain, which runs up to one's fingertips even, is known to most of you. Compression of sensory nerves is believed to cause contraction of the cerebral vessels, as recently shown by experiments on rabbits. Possibly this explains too the faints which follow severe pain.

All these are symptoms of concussion in the peripheral nerves. As we are not aware of what specially takes place in the nerves, we cannot judge whether these changes have any and what influence on the further course of contusions and of contused wounds; we cannot then here further consider the nerves. Reliable observations seem to show that concussion of peripheral nerves may be followed by motor and sensory paralysis of the muscles of a part, but on account of many complications it is very difficult to prove any connection between the two. We must distinguish contusions from concussion of nerves. In the former, individual portions of a nerve trunk or the entire thickness of a nerve trunk may be destroyed to a greater or less extent and degree by the violence applied, so that we may even find them softened to a pulp. Under such circumstances a corresponding paralysis results, from which we are able indeed to recognise the affected nerve, and the extent of the injury it has received. On the whole, such contusions of nerves without open wounds are rare, because the chief nerve trunks are situated deeply between the muscles, and are hence less liable to direct injury.

It is acknowledged, *à priori*, that other tissues and organs are influenced by shock just as are the nerves, and that disturbances not only of the ordinary functions of a part, but also of the nutritive or growing powers, temporary or permanent, may be brought about. Such disturbance of function may have an important influence on the further course of the reparative changes after accidents; many surgeons regard this as the chief cause of the severe inflammatory processes, with their easily decomposing exudations and infiltrations, so often met with after injuries. I am far from denying the influence of a severe concussion on a bone; for instance, the medulla and vessels may be torn, although the bone is not fractured; the consequences of such an injury under certain circumstances may be much more extensive and far-reaching than a mere

fracture from overstraining; nevertheless, we must not attribute the sometimes very severe after-effects of contused wounds entirely to this cause.

Contusion of vessels is often sufficiently obvious, and is recognised by the presence of blood, which, owing to injury of the walls of the smaller vessels, especially of the subcutaneous veins, becomes extravasated. Subcutaneous hæmorrhage is thus an almost constant result of contusion. It would be even more considerable than it is if the wound of the vessels in this class of injuries were clean cut, and remained open; but generally this is not the case; contused wounds of vessels are rough, uneven, jagged, and these inequalities all offer so many hindrances to the escape of the blood; the friction is so great, in fact, that the blood pressure is no longer able to overcome it, fibrinous coagula attach themselves to these points, spread into the interior of the vessels, and so a mechanical plugging of the vessel—a thrombosis—takes place. The contusion of the wall of a vessel, through which an alteration in its structure is brought about, can alone cause coagulation of the blood; for Brücke has shown that a healthy living intima is an important condition for the preservation of the fluid condition of the blood within the vessels. We shall again refer to this subject under contused wounds. The resistance of the soft parts prevents an excessive extravasation of blood, because both muscles and skin exercise a natural compression; thus, it rarely happens that subcutaneous hæmorrhages in the extremities, even when they proceed from large vessels, are immediately dangerous to life. Of course it is quite different with hæmorrhages into the large cavities of the body; here the eminently moveable soft parts cannot offer any sufficient impediment to the escape of the blood from the vessels; such hæmorrhages are thus then not unfrequently fatal; death may result in one of two ways, either from the amount of blood poured out, as into the thorax or abdomen, and partly from the compression which the extravasating blood exercises on the surrounding organs, as on the brain, which may not only be destroyed by the quantity of blood, but also compressed in various directions and so rendered incapable of performing its functions. Hæmorrhages into the brain thus rapidly cause paralysis, and often also sensorial disturbance; we call these hæmorrhages into the brain, and also the train of symptoms which they produce apoplexy (from ἀπο and πλήσσω, to beat away, to knock down).

If a large artery in an extremity be torn, the conditions are the same as in a punctured wound which has been sewn up or compressed; a traumatic aneurism, a pulsating blood-tumour, as described in the last lecture, may result. This, in proportion to the large number of contusions which daily occur, is a very rare accident; it is to be explained partly by the fact that the arterial trunks are deeply seated, and partly because their walls are tough and elastic and thus they are very much less often torn than the veins. Nevertheless, a short time ago we had in our wards a case of subcutaneous rupture of the anterior tibial artery. A strong heavy man had broken his leg, but the skin was uninjured. The seat of fracture was about the middle of the tibia, and a little higher up in the fibula; a rather large tumour quickly formed at the seat of the injury, it pulsated considerably; this pulsation could be both seen and felt on the anterior surface of the leg. A loud murmur was distinctly audible in it, and I was able to demonstrate it to my class. The leg was put up in a splint and bandage, but we purposely avoided the application of an immovable dressing, in order that we might the better observe the further course of the traumatic aneurism, which had manifestly formed here. We renewed the dressing every three or four days, and were able to convince ourselves that the tumour gradually became smaller and pulsated less and less every day, until, at the end of a fortnight, the pulsation had entirely ceased. This aneurism was cured by the compression which we made with the bandage. The healing of the fracture too progressed uninterruptedly; and the patient, at the end of eight weeks from the accident, had recovered complete use of his limbs.

Subcutaneous hæmorrhages after contusions are most frequently due to rupture of the subcutaneous veins. The exudations produce visible symptoms, which vary according to the quantity of the extravasated blood and its distribution in the tissues.

The more vascular the part, the more severe the contusion, the greater is the extravasation. Extravasated blood, when it is poured out slowly, burrows between the layers of connective tissue, especially into the subcutaneous tissue, or into the intermuscular planes. In this the tissue becomes infiltrated with blood, and swelling results. These diffuse and subcutaneous hæmorrhages are called sugillations (fr. suggillatio—extravasation), or suffusions. The looser and more yielding the tissue, the easier is it to tear apart, and hence then the more extensive will be the infiltration if

the blood can slowly but continuously escape. Thus we usually find extravasations into the eyelids or scrotum of considerable extent, because here the subcutaneous connective tissue is so very loose. The thinner the skin the more easily and the more quickly do we recognise the infiltrated blood; it shows through the skin, and penetrates into it, giving it a bluish colour. But beneath the ocular conjunctiva extravasated blood looks quite red, because this membrane is so transparent and thin. Extravasations of blood in the cutis itself appear as red spots (purpura) or as 'stripes (vibices); in this form they are seldom the result of contusion, but are rather caused by spontaneous rupture of vessels. It may be that in some persons the vessel walls are peculiarly thin, as in bleeders, of whom we have already spoken, or that, in consequence of some unknown chemical changes in the blood, the vessels become brittle and liable to tear, as in scurvy, in [many forms of typhoid, and in purpura hæmorrhagica. Contusions of the cutis may generally be recognised by the deep blue-brownish colour, sometimes also by the stripping off of the epidermis, or as it is technically called, excoriation.

If a quantity of blood escapes suddenly from the vessels, and is poured out into loose cellular tissue, a more or less circumscribed cavity results. This form of effusion of blood is called ecchymosis, ecchymoma, or hæmatoma, a blood tumour; whether the skin is discoloured or not depends on how deep the blood lies beneath it; in deeply seated effusions of blood, diffused as well as circumscribed, we often get no discoloration of the skin, directly after an accident especially. We can only recognise swelling, the rapid development of which, however, immediately after an accident, at once suggests its nature; this swelling feels soft and tense. A circumscribed effusion presents the very characteristic feeling of undulation—a sense of fluctuation. You can obtain the clearest idea of this feeling by filling a bladder full of water and then palpating its walls. The detection of fluctuation is of great importance in surgical practice, for there are numberless cases where it is important to distinguish whether a given tumour is solid, or is one containing fluid or very soft tissue. How best to undertake this examination in undivided cases you will learn in the wards.

Some of these effusions of blood have received special names according to the localities in which they occur. Thus effusions of blood, which not unfrequently occur on the scalp of newly-born in-

fants, are called cephalhæmatoma (from κεφαλή, the head, and αἱματόω, to besmear with blood). The extravasation which forms in the labia majora either after contusion, or spontaneously from rupture of distended veins, has received the euphonious name of episiohæmatoma or episiorrhagia (from ἐπείσιον, the external genitals). Effusions of blood into the pleuræ and pericardium also have special designations—hæmatothorax and hæmatopericardium, &c. Now-a-days little importance is attached to these high-sounding Greek and Latin names; it is necessary, nevertheless, that you should know them, partly in order that you may understand them whenever you see the terms in your medical books, and partly because it enables us to express ourselves more briefly and more readily.

The subsequent course and symptoms of these subcutaneous effusions of blood are very characteristic. Let us first consider diffuse extravasations; in such cases, immediately after the accident, we are quite unable to say how extensive the hæmorrhage has been or still is. If you examine a contused part two or three days after the injury, you will observe that the discoloration is much more extensive than on the first day; even this appears to extend subsequently, that is, it becomes more appreciable. The extent is at times quite incredible. We once had under care a man with fracture of the scapula; at first the discoloration was very slight, although a large fluctuating swelling was present; on the eighth day the whole of the back from the neck down to the region of the gluteal muscles had assumed a dark bluish colour, and looked as if it had been painted. These extensive extravasations are especially common after fractures of the leg or arm. These dark blue or bluish-red discolorations, with which the skin is never tender or much swollen, do not fortunately remain; some further changes set in, the first of which is another change of colour; the blue and red become brownish, then green, and lastly yellow. This peculiar play of colour has given rise to the expression of "beating one black and blne;" that is, giving one a sound thrashing. The final colour, the yellow, usually remains for a long time, even for months; and then this also disappears, and no external trace of the extravasation remains.

If we now inquire how these various discolorations of the skin are brought about, we find if we have an opportunity of examining blood extravasations in different stages that it is a colouring matter of the blood, which gradually undergoes these metamor-

phoses and gives rise to these varying shades of colour. When blood escapes from the vessels, and gets into the connective tissue, the fibrin coagulates. The blood serum permeates the connective tissue and gets back again into the vessels; it is reabsorbed. The colouring matter of the blood leaves the corpuscles; it too gets in a state of solution into the connective tissue. The fibrin and the blood corpuscles break up for the most part into fine molecules, are become absorbed as such by the vessels. A few of the white corpuscles perhaps, as in thrombus, may possibly be further developed. The blood-colouring matter which pervades the tissues undergoes certain subsequent changes which are not very well understood, until it is finally converted into a permanent colouring matter, which is no longer soluble in the fluids of the organism—hæmatoidin.

FIG. 44.

Granular and crystallised hæmatoidin, orange and red colour. Magnified 400.

As in a thrombus, this is partly granular, partly crystalline. In its pure condition it is of a dark orange or of a ruby-red colour; when sparingly distributed, it gives the tissues a yellowish colour, when more plentifully present, a deep orange tinge.

Absorption of the extravasation always takes place in diffuse suggillation, because the blood is widely distributed in the tissue, and the vessels which have to do the work have not suffered from the contusion; this is the most desirable, and under favorable circumstances the most frequent termination of subcutaneous and intermuscular effusions of blood.

In circumscribed effusions—in ecchymoses—the case is somewhat different. It depends in the first place on the extent of the effusion, and next on the state of the vessels in the surrounding tissues; the more numerous they are, the less are they injured by

the contusion, the more likely is it that absorption will take place. Nevertheless, absorption in large effusions of this kind is at the best uncertain. There are various causes which prevent this; first of all, a thickening of the connective tissue around the effused blood, as around a foreign body (as also in traumatic aneurism), takes place, by means of which the blood becomes encapsuled; then on the interior surface of this sac fibrin is deposited in layers, and fluid blood remains in its centre. Thus the vessels around this blood tumour can only absorb a very limited amount of fluid, because they are separated from the fluid parts of the blood by a thick wall of fibrin. We here get the same conditions as are present in large adhesive exudations into the pleural cavity; the layers of lymph which are deposited on the chest walls interfere with reabsorption. It can, in fact, only take place under these circumstances by molecular disintegration of the fibrin, and by its becoming fluid again; or after it has become organised and provided with lymph and blood-vessels. This is not at all uncommon in the pleura. There are many other terminations for these extravasations. For instance, the fluid portions of the blood may become entirely absorbed, and a firm hard swelling arranged in concentric layers (like an onion) remain behind. This happens every now and then with extravasations into the labia majora, and in this manner a fibrous tumour results. These connective-tissue tumours may also form in the uterus under like circumstances. Many hæmatomata become organised into connective tissue; they may also take up salts of lime, become calcareous, and calcify; on the whole this is a rare termination, but one which does happen, for instance, in effusion of blood into large goitres, and also occasionally in the walls of large traumatic aneurisms. Another way is the transformation of the blood tumour into a cyst. This is observed in the brain, also in soft tumours. Many of the cysts in goitres, along with other modes of origin, may possibly be explained in this manner. By a cyst or encysted tumour we mean a sac or cavity with more or less fluid contents. The contents of a cyst resulting from extravasation of blood are of a darker or lighter colour according to their age; the blood-colouring matter may entirely disappear, and the contents become quite white in colour, or be only tinged by molecules of fat. In large circumscribed extravasations you will find well-formed crystals of hæmatoidin less abundant, and less often than in smaller and more diffuse extra-

vasations: in the former fatty degeneration of the elements of the blood is more manifest, and this leads rather to the production of crystals of cholesterine. The capsule which encloses these old blood effusions is formed partly by organisation of peripheral portions of the blood-mass, and partly from the surrounding structures.

Suppuration of circumscribed extravasations is far more common than the last two metamorphoses which we have just described, but this is not so common as reabsorption. The inflammatory process around, and the plastic processes in the peripheral portion of the extravasated blood through which, in the two preceding instances, the thickened connective tissue which enclosed the blood was developed, assume a more acute character in the case we are about to describe; here also a limiting layer is formed, but not slowly and gradually as in the last cases, but by a rapid cell-development; this plastic infiltration of the tissue does not lead on to the development of connective tissue, but to suppuration; the inflammation spreads to the cutis, and this also suppurates from within outward, and finally perforates; the pus, mixed with blood, is then evacuated, the walls of the cavity fall together, shrink and close up: in this way healing takes place. We shall have to speak of this mode of healing when treating of abscesses; we are accustomed to call any pus-tumour, that is, a circumscribed collection of pus anywhere beneath the skin, an abscess, and thus we speak of the above process as the suppuration of extravasated blood. This process may take place very slowly; it may even last three or four weeks, but, unless dangerous from its position, it generally runs a favorable course. We recognise the advent of this suppuration by an increasing inflammatory redness of the skin, the increase in size of the swelling, the increasing pain, occasionally accompanied by fever, and lastly by the thinning of the skin at the point where perforation finally takes place.

Lastly, there may be rapid decomposition—sloughing of the extravasation, in fact; fortunately this is rare. In this case the tumour becomes hot and tense, exceedingly painful; the temperature generally rises to a considerable degree; rigors and other severe symptoms may also occur. This termination, which only occurs after very severe contusions, and with subsequent acute secondary inflammation, is the most serious of all, and indeed the only one, which calls for immediate surgical interference.

Whether there shall be absorption, suppuration, or decomposition of an extravasation depends not only on the amount of the effused blood, but more especially on the degree of contusion which the tissues have undergone; so long as these can return to their normal condition absorption of the effused blood is probable; if, on the contrary, the tissues are destroyed and break down and decompose, then the suppuration and sloughing will extend also to the blood; briefly, the effused blood will undergo the same fate as the contused tissues.

The differences which characterise the course of subcutaneous contusions and those which are open (compound) contused wounds are so remarkable that surgeons have long had them under consideration. Absorption of the extravasated blood, and molecular disintegration of the contused and dead tissue without any decomposition, often indeed without any symptoms of inflammation, are the rule in cases of slight subcutaneous contusions; suppuration and sloughing are the exception; but in contused wounds, on the contrary, suppuration and sloughing of the contused tissue ordinarily occur. Formerly the unfavorable influence was sought in the contact of the contused tissue with the air, especially with the oxygen of the air; more recently pure air is considered less injurious; it is only air rendered impure by the germs of minute organisms which is dangerous. To protect contused wounds from these germs is the object which has influenced Lister in the plan of construction of his antiseptic dressings; he endeavours to obtain (artificially) the same conditions for contused and deep-seated wounds as obtain in subcutaneous contusions, in order to get the same result, that is, absorption without either inflammation or decomposition. I must refer the reader to what has already been said on this subject (p. 135).

We cannot accurately judge the extent of the contusion of muscles, tendons, and fasciæ in cases where the skin is uninjured; the extent of the extravasation, however, may sometimes help us, but it is at best an uncertain guide; of more importance is the amount of functional activity of the affected muscle, though here again the results obtained must be carefully weighed; the amount of force which has operated on the part will lead to the most reliable estimation of the amount of damage done. The healing of contused muscles takes places, as in wounds, by molecular degeneration of the contused part and subsequent absorption. In

suppuration of the extravasated blood the muscular elements are discharged with the pus, and then subsequently a formation of connective tissue and also of new muscular fibres may take place. The largest extravasations, both diffuse and circumscribed, are generally accompanied by injury to the bones. It will be better to consider injuries to bones in a separate chapter.

When a portion of the body is so injured as to be either in part or entirely incapable of living, it becomes cold, bluish-red, or brownish-red, and then black; it begins to mortify, and the products of decomposition get into the neighbouring tissues and into the blood; the local inflammation and also the fever take on unusually severe forms. As this is the same for contusions either with or without wounds, we shall speak of it later on.

The object of the treatment of simple contusions (contusions without wounds) is to conduct the process to the most favorable termination possible, that is, to absorption of the extravasation; when this takes place, the injuries sustained by the soft parts also progress favorably, because the whole process remains subcutaneous. We simply refer here to those cases where the contusion of the soft parts and the extravasation alone require treatment; in cases complicated with fracture it is the latter which must before all be treated, and the extravsaation itself will scarcely require any special measures. If we are called to a contusion which has just occurred it becomes our duty to arrest the hæmorrhage if it seem to be still going on. This will be best secured by compression, which, when possible, is to be obtained by well-applied bandages. When a child falls on to the head, or knocks its forehead, it is the custom in North Germany for the mother or nurse to take the handle of a spoon or the blade of a knife and press it firmly on to the injured part, in order to prevent the formation of bruise-marks. This is a very useful popular remedy; by this timely compression the further escape of blood is prevented on the one hand, and on the other the blood which does escape is made to distribute itself in the surrounding tissues and not allowed to collect at any one point; an ecchymosis just forming may in this way be transformed into a simple bruise; the blood is thus more readily absorbed.

But we rarely see the injury sufficiently early, and so in a vast majority of cases we have to deal with an injury either of a bone or of a joint as well as with a contusion, which latter then of course falls into the back ground.

The use of cold, applied by means of ice enclosed in a pig's bladder or an india-rubber bag, or cold-water applications to which it is a popular custom to add vinegar or liquor plumbi, are the means to be employed in recent contusions; they no doubt frequently prevent much subsequent inflammation. You must not, however, count too much on these remedies; the means by which the absorption of extravasated blood is best furthered are by uniform compression and absolute rest of the part. Thus it is best to apply wet bandages to the extremities, over which wet cloths may be applied, which must be renewed every three or four hours. Other remedies which usually act favorably in acute inflammations of the skin, such as mercurial ointment, are of little avail in these cases. I must not forget arnica! This remedy is so honoured by some families and physicians that it would be considered unpardonable to neglect prescribing it in contusions; compresses soaked either with an infusion or with water to which some of the tincture has been added may be applied. Belief is all-powerful; some believe in arnica, some in lead lotion, others in vinegar, as the most powerful external absorbent. Probably the faith in arnica would somewhat decrease if the public was aware that eczema and erythema of the skin not infrequently follow its use. In all cases doubtless the effect is due to the moisture and to the changes in temperature consequent on its application; the capillaries are kept constantly active, at one time contracted, at another dilated, and so they are best adapted for absorption because they are active.

Diffuse extravasations of blood, with only moderate contusion of the soft parts, are generally absorbed without much treatment. If a circumscribed extravasation does not materially alter in the course of about fourteen days, there is nevertheless no indication for active interference. The tumour must be painted with diluted tincture of iodine once or twice daily, and compressed by means of an appropriate bandage: under such treatment it will not unfrequently subside in the course of a few weeks. If it become hot, and the skin over it inflamed, reddened, and painful, we must be prepared for suppuration; even the continued application of cold will now seldom alter the course, though it may possibly moderate it. And now, in order no longer to retard the suppuration which we cannot prevent, we may apply hot fomentations, either with folded cloths, wrung out of hot water, or with poultices; we now quietly await the course of events; if no aggravation of symptoms occur, if the

patient feel pretty well, we may wait patiently for suppuration; the skin will gradually thin at one place (though this may not take place for weeks), and at last an opening will be made, the pus will discharge itself, the walls of the cyst will fall together, and in a short time healing will be complete. At the commencement of this lecture I mentioned a case where, after fracture of the scapula, an enormous, partly diffuse, partly circumscribed extravasation was formed. Here was a highly fluctuating swelling, which persisted and was not absorbed; though the diffused portion was rapidly removed, it was five weeks after the accident before the suppuration broke through, and then between two and two and a half litres of pus were evacuated. Eight days later this enormous cavity was healed up, and the patient left the hospital quite cured.

If, in the course of the suppuration of an extravasation, the tension of the swelling should rapidly increase, and a high temperature with rigors occur, you may infer that decomposition of the contents of this tumour has set in. With such symptoms the putrid fluids must be quickly let out. This is best done by making a free incision through the skin, whenever the anatomical relation of parts will allow it; otherwise several smaller incisions must be made, and in such a position as will allow a free exit for the discharge. These incisions of course entirely alter the aspect of the case, for you have made a subcutaneous contusion into a compound one. Other conditions now come into play, which we will consider in our next lecture. We must, however, just mention, that in case of extensive gangrenous breaking down of the soft parts after such contused wounds, amputation is indicated, although, without simultaneous fracture of the bones, such unfavorable cases rarely happen.

LECTURE XII.

CHAPTER IV.

CONTUSED AND LACERATED WOUNDS OF THE SOFT PARTS.

Mode of occurrence of these wounds; their appearance.—Slight hæmorrhage in contused wounds.—Early secondary hæmorrhage. —Gangrene of edges of the wound; influences which effect the slower or more rapid detachment of necrosed tissue.—Indications for primary amputations.—Local complications in contused wounds.—Decomposition.—Putrefaction.—Septic inflammations.—Contusions of arteries; late secondary hæmorrhage.

THE causes of contused wounds, of which we have to speak to-day, are the same as those of simple contusions, except that in the former the force employed is usually much greater than in the latter; it depends also on the form of the wounding instrument, whether it is such as to divide the soft parts easily, and further on the part of the body struck, whether the skin over it is particularly thin, or whether it is supported on a firm subcutaneous basis.

The kick of a horse, a blow from a stick, the bite of an animal or a man, being run over, injuries with blunt knives, with saws, &c., are frequent causes of contused wounds. Nothing, however, cause more contused wounds than rapidly revolving machine wheels, iron rollers, circular saws, spinning machines, and machines with wheels and cogs. All these instruments, the productions of an ever-advancing industry, are the causes of much mischief amongst the working classes. Men and women, adults and children, with crushed fingers, smashed hands, jagged and lacerated arms and fore-arms, are always to be found in the surgical wards of any large hospital. If to these we add the now somewhat rarer cases of railway

accidents, and those caused by the blasting operations of building tunnels, &c., you will see, not only how much sweat, but also how much blood, cling to the evidences of modern culture. At the same time it is not to be denied that the chief cause of these accidents for the most part is the carelessness, often indeed the foolhardiness, of the working man. Daily contact with dangerous machines renders people at last careless and rash, and many pay for this with their lives.

Gunshot wounds for the most part belong to the class of contused wounds; but as they have many peculiarities of their own, we shall consider them in a separate chapter. Lacerated wounds, and the complete tearing out of portions of a limb, will be considered towards the end of this chapter.

Contused wounds from all the above-named causes are very frequently complicated by the most varied and often dangerous fractures; for the present, however, we shall leave these injuries out of consideration and treat only of the soft parts.

The appearance of a wound generally indicates whether it is due to incision or contusion. You are already familiar with the characteristics of a clean-cut wound, but I have already pointed out to you some cases in which a contused wound may resemble an incised wound and *vice versá*. Contused wounds, just as incised wounds, may be accompanied by loss of substance, or may consist in a simple solution of continuity. The edges of these wounds are for the most part very uneven and shreddy, especially the edges of the skin; the muscles sometimes look as if they had been chopped, and shreds of the soft parts in larger or smaller pieces, not infrequently in large flaps, hang down into the wound stained with the blood, which is either stagnated or effused within them. Tendons are occasionally ruptured or torn out, fasciæ are torn, the skin around the wound, often to a great extent, is separated from the muscles, especially if the contusing was combined with a tearing and a twisting force.

The degree of destruction of the soft parts is naturally very variable, and its extent cannot always be accurately ascertained, as we cannot always see how far the contusion and tearing extend beyond the wound; often enough during the subsequent course of a wound we may convince ourselves that the contusion extended much further than the size of the wound indicated and that the separation of muscles, the tearing of the fasciæ, the effusion of blood, have

extended far beyond the portion of skin which was ruptured. It is an unfortunate circumstance that the external wound affords no guide for judging of the extent and depth of the contusion, and thus it is very difficult to correctly estimate the extent of such an injury at the first examination, and thus while the outward appearance of the wound gives the layman no idea of the danger, the experienced surgeon soon recognises the gravity of the case.

Since the injury, especially when done by machinery, is very rapidly inflicted, the pain is not great, nor is the pain of contused wounds shortly after their infliction particularly severe; in fact, the greater the injury and more crushed a part is, the less considerable is it. This is easily explained by the nerves in the region of the wound being completely crushed and destroyed, and consequently incapable of conducting impressions; besides this, the so-called concussion ("stupor") of the injured part, to which I referred in the last lecture, here comes into play.

At first sight it seems remarkable that these contused wounds bleed so little, if at all, even though large veins or arteries be crushed or torn. There are authentic cases on record where after complete crushing of the femoral or axillary artery no primary hæmorrhage took place. This certainly is not of frequent occurrence; in many cases after a complete rupture of an artery of such large size, there is a constant oozing of blood, if not an actual spirt, and such, coming from the femoral artery, for instance, would quickly cause death. I have already pointed out how the arrest of hæmorrhage takes place in smaller arteries, but I will make it clear to you by giving an illustration. A railway labourer was run over by an engine, the wheel of which passed over his left thigh just below the hip-joint. The unfortunate man was immediately brought to the hospital on a stretcher; apparently he had lost much blood by the way, and on his arrival he was very pale and bloodless, but perfectly conscious. After complete removal of his tattered clothes we found a horrible mangling of the soft parts of the region mentioned. The bone was smashed into about thirty pieces, the muscles were crushed into a pulp, and hung out of the wound in shreds; the skin was ploughed up as far as the hip-joint. At no point of this immense wound did an artery spirt, but blood constantly welled up from the deep parts in no inconsiderable quantities, while the general condition of the patient plainly showed that he had already lost blood to a considerable extent. It was

obvious that nothing short of exarticulation at the hip would avail; yet in the then condition of the patient this was not to be thought of, for the additional loss of blood (Esmarch's method was then not thought of) which such an extensive operation would necessarily have entailed would certainly have been fatal. Before all things, then, it became necessary to arrest the hæmorrhage which probably came from a tear in the femoral artery. I first of all endeavoured to find the femoral artery in the wound, while it was compressed higher up, but the muscles were all so much misplaced, twisted, and their anatomical relations so altered, that it could not be quickly done, so I proceeded to ligature the femoral artery below Poupart's ligament. After this was done most of the bleeding ceased, though not entirely on account of the rich arterial anastomosis, and so, as no regular bandage could be applied on account of the extensive lacerations, I applied a tourniquet just below the spot where I meant to exarticulate, and screwed it firmly up. The bleeding now left off; we administered various restoratives in order to bring the man round; he had wine and warm drinks, so that towards evening he had again so far recovered that the temperature had gone up to normal, and the radial pulse was again fairly good. I should have postponed an operation until the following day but that, in spite of ligature and tourniquet, the hæmorrhage again commenced as the heart's power increased, and I feared the man might bleed to death during the night. I therefore performed exarticulatio femoris with the able help of my assistants, and did it as rapidly as I could. The loss of blood during the operation was not considerable absolutely, but it was relatively much for the already debilitated patient. At first all seemed to go on favorably, the spirting vessels were all tied, the wound was closed up, and the patient put back to bed; he soon, however, became very restless and dyspnœa set in: this increased more and more and finally convulsions occurred; the patient died two hours after the operation.

The examination of the femoral artery of the smashed extremity showed a lacerated wound, situated in the upper third of the thigh, involving a third of the calibre of the vessel. Not only the shreds of the tunica intima, but also the other arterial coats, had curled themselves up into the lumen of the vessel, so that the blood escaped from it with great difficulty; the surrounding structures were completely saturated with blood. In this case no clot had formed

in the artery, as the escape of blood was too free to permit of this; yet when you come to consider that the artery was injured in its entire circumference, you will easily see how the torn shreds of the arterial coats, pressing from all sides into the lumen of the vessel, might have rendered the escape of blood still more difficult or even impossible; in that case a thrombus would have formed, which would have plugged the vessel and then have gradually organized or have broken down and putrefied. If no hæmorrhage had followed the partial contusion of the artery, for instance, if the entire contusion had been a simple one (with no external wound), probably a clot would have formed in the artery at the spot injured by the contusion, a clot or thrombus in the wall of the vessel (ein wandständiges Gerinnsel); in such a case the contusion of the artery might have been followed by preservation of its calibre—a result which is said to have sometimes been observed.

Apply the conditions above described of a contused large artery to the smaller arteries, and you will quickly see how much more easily complete spontaneous closure of the lumen of the vessel may take place, partly by the rolling in of the brittle torn tunica intima, and partly by the contraction of the tunica muscularis, and also by the shreds of the adventitia; so that in such-like contused wounds hæmorrhage may be entirely absent. These observations led to the invention by the French surgeon Chassaignac of an instrument by means of which a diseased part of the body may be taken off; he terms the operation "écrasement," and the instrument an "écraseur." It consists of a strong loop of metal, made up of a number of small links rivetted together, which is placed around the part about to be removed; the loop is then tightened with the aid of a rackwork apparatus, contained within the handle of the instrument, which is hollowed for that purpose. And indeed, if the instrument be properly handled, not a drop of blood need be lost; and although this method found little sympathy among surgeons at first, because contused wounds are avoided as much as possible in operative surgery, yet for certain cases its practical value is beyond all question. Healing of wounds caused by "écrasement" takes place with unusually little local or constitutional reaction; secondary inflammations are associated with this class of wounds less frequently than with clean-cut wounds; nevertheless, his operation is applicable only in a relatively small number of cases.

There is yet another point to consider, which tends to limit

hæmorrhage in extensive contusions, and that is, the depression of the heart's action caused by the injury; this is probably produced by reflex action. Persons who are seriously injured, quite irrespective of the loss of blood and of injury of nerve-centres, are usually stupid and stunned; we have no German word to express this state of depression, and so the English word "shock" is used. It signifies a condition of great depression after an injury. The fright of the injury, and all thoughts about it, which follow in rapid succession, probably combine to produce a considerable mental depression, which has a paralysing effect on the heart's action. Still, even in persons who are not much mentally affected by an accident, such as is the case in old soldiers who have been frequently wounded, or in persons of a very phlegmatic disposition, the shock of an accident is not entirely absent, and thus we are led to the conclusion that shock is really due to reflex causes. Contusions of the abdominal viscera have a more depressing effect on the nerve-centres than even contusions of the extremities, as I have already pointed out. In connection with this subject the so-called "Klopfversuch" (percussion experiment) of Golz is interesting. If a frog be repeatedly struck on its abdomen with the handle of a scalpel, it will become temporarily paralysed through anæmia of the brain; the abdominal vessels dilate widely in consequence of paresis of their walls, and thus appropriate a great portion of the blood, so that the remaining vessels and even the heart become bloodless, while the latter only feebly contracts.

Then when the patient has recovered from this mental and physical depression, and when the heart is again acting with its former or even with more vigorous energy, hæmorrhage may take place from vessels which at first did not bleed. This is a variety of secondary hæmorrhage, such as occurs after operations, when the chloroform narcosis has passed off. The patient must therefore be carefully watched during this period in order to guard against such dangerous hæmorrhages, especially if, in consequence of the position of the wound, there be any reason to suspect that a large artery has been injured.

We will next examine somewhat more attentively the local changes which are taking place in the wound.

Though the processes which take place in contused wounds, the superficial changes as well as the ultimate healing of the wounds, are essentially the same as in incised wounds, there are yet con-

siderable differences in the manifestations of these processes in the two cases. One very important point to remember is that in contused wounds the nutrition of the edges of the skin and of the soft parts is more or less extensively interrupted or may be even completely destroyed. More anatomically expressed this signifies that the circulation, the nutritive juices, and the nerve influences are more or less absent from the edges of contused wounds in consequence of the injury sustained by the vessels, tissues, and nerves. Thus the contused and gangrenous edges of such a wound cannot possibly heal by the first intention, since this process absolutely requires complete vitality of the wound surfaces. These contused wounds, the edges of which have been injured, always heal by granulation. This observation has led to the practice of never putting in sutures in contused wounds, and of not even closing them with strapping. You may consider this as the general rule. There are of course exceptions to it which you can only learn by practice in the wards, and concerning which I will for the present only just remark, that occasionally large loose skin flaps are adjusted into their proper position, not in the expectation that healing by the first intention will take place, but in order to prevent too great retraction and too much atrophy afterwards. Contusion, laceration, tearing, are variously combined, but it depends in each case whether or not the edges of the wound are capable of repair.

The formation of granulations and suppuration subsequently are the same as in wounds with loss of substance, only with this difference that repair takes place more slowly, and in many places even more imperfectly. Occasionally also, no doubt, in incised wounds with loss of substance, there is loss of a superficial layer of tissue if the nutrition is not adequate; but this is very insignificant in comparison with the extensive flaps of tissue which sometimes slough after contused wounds. These shreds of dead (necrosed) skin, fasciæ, tendons, hang from the wounds for days, and even weeks, while other parts are granulating luxuriantly.

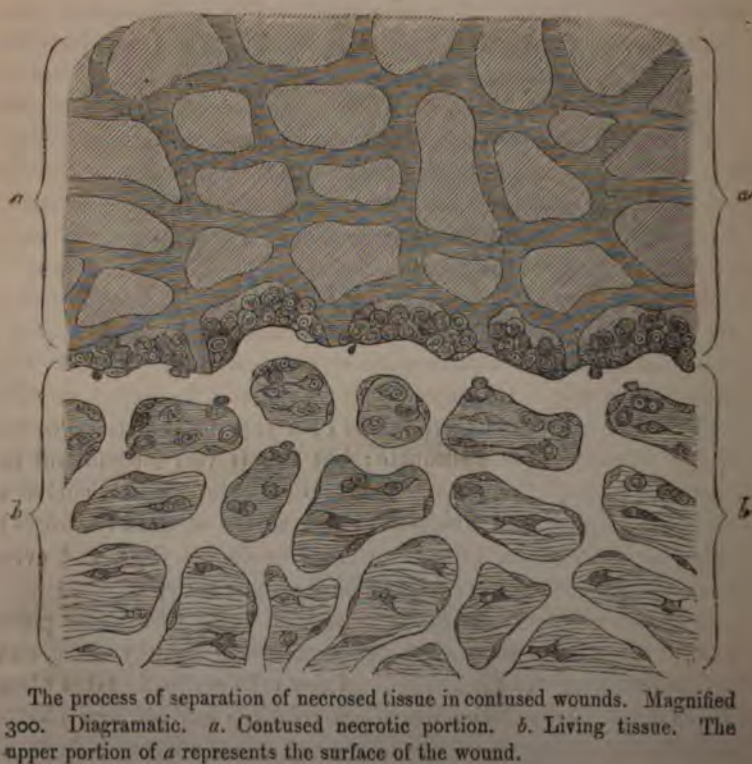
The process of detachment of dead from living tissue takes place as follows:—along the margin of the uninjured, healthy tissue, and proceeding from it, an infiltration of new cells gradually takes place which leads to the formation of granulations and of new blood-vessels; the surface of these granulations soften and pus is formed. As a result of this softening, to a certain extent a dissolving and melting away of the tissue, the cohesion of the parts naturally ceases

and the dead tissue which on account of its fibrous nature still clings to the living, must at last fall off.

Thus a portion of the surface of a contused wound will almost always become gangrenous or necrotic (from *νεκρός*, death, and *ἡ γάγγραινα* from *γραίνω*, to consume)—expressions which are used synonymously for parts in which both circulation and innervation have ceased, and which are dead. The spot at which the detachment of the gangrenous portion takes place is called the line of demarcation.

I will endeavour to make this process of separation of the dead from the living tissue by means of the formation of granulation and suppuration a little more intelligible by the following diagram.

FIG. 45.



The process of separation of necrosed tissue in contused wounds. Magnified 300. Diagramatic. *a*. Contused necrotic portion. *b*. Living tissue. The upper portion of *a* represents the surface of the wound.

In the portion of tissue here represented the edge of the wound

is supposed to be so contused that the circulation has ceased, and it is no longer nourished, the blood in its vessels has coagulated as far as the shading extends in the drawing. Cell infiltration and inflammatory new growth is commencing at the extreme edge of the living tissue, between *a* and *b* where the vessels terminate in loops; these loops dilate, and increase by a process of budding, and multiply; the infiltration in the tissue is increased by the wandering cells, just as if this were the edge of the wound. Granulations form, the surface of which breaks down, that is, the surface adjoining the necrosed part; so that the latter naturally falls off because its adhesion with the living tissue has ceased.

The separation of the necrosed portion then is brought about by the formation and suppuration of granulation tissue. When the dead tissue has fallen off, the subjacent suppurating layer of granulations comes to light, as it was already developed before the necrosed portion was detached; what you here see in connective tissue is true also of other tissues, bone not excepted.

In many cases it is possible to judge from the fresh edges of the wound how much of them will necrose, but not by any means in all cases, and it is never possible to foretell exactly where the line of demarcation will appear.

When the skin is badly contused it usually has a dark blue or violet appearance and is cold to the touch; in other cases there appears to be no change in it at first, but in a few days it becomes colourless and absolutely devoid of sensation; then it turns to a grey colour, or if it dry up completely, to a greyish black or brownish black. The variations in colour depend chiefly on the amount of coagulated blood, which is contained in the vessels, or as a result of their rupture in the tissue itself. The healthy skin, on the contrary, is bounded by a rose-red line which gradually diffuses itself. This redness is the result partly of collateral dilatation of the capillaries, and partly a congestive and inflammatory symptom, which we have already spoken of at length; it is the redness of reaction about the wound which has been described elsewhere, for the healthy surface of a wound only begins where the capillaries are charged with circulating blood.

Much less frequently, and often not at all, can we foretell from first appearances how much muscle, fascia, or tendon will slough off.

The time required for the dead tissue to be separated and detached

from the living, greatly varies with the different tissues. It chiefly depends on the vascularity of a part; the richer a tissue is in capillaries the softer it is, and the more easily do cells spread through it; and, according to its structure, the richer it is in cells which are capable of organization, the more quickly will the formation of granulations and the separation of the dead portion take place. All these conditions best obtain in the subcutaneous cellular tissue, least so in tendons and fasciæ; the cutis, in this respect, occupies an intermediate position. The conditions for the bones are most unfavorable; the separation of the dead from the living bone takes place most slowly, but of this anon. A rich supply of nerves seems to count for little in the process.

But there are many other influences which hinder the rapid separation of the necrosed parts, or, what is the same thing, retard the formation of granulations and of pus. Among these may be mentioned the continued action of cold on a wound, such as may be affected by the application of ice. As a result of the low temperature the vessels are kept in a state of contraction, the movements of leucocytes are retarded, and the cell proliferation diminished. The contrary obtains by the application of constant warmth; by this means we increase the blood-flow to the capillaries, and compel them to dilate, as you may see by the redness which immediately appears even on healthy skin when you apply a hot poultice. Besides this, it is well known that warmth favours cell-movements.

It is altogether impossible also to foretell the influence of the constitutional peculiarities of the patient himself on the course of the above processes, but in general we may say that they are more energetic in young, strong muscular individuals, and more moderated and sluggish in weakly individuals. But in this one is often mistaken. The course of contused wounds is particularly unfavorable in old drunkards.

From what has been said you will be able to gather that contused wounds require a much longer time to heal than the generality of simple incised wounds. It will also be evident to you that there may be circumstances which necessitate the amputation of a limb, as when the soft parts are completely smashed and lacerated. There are, indeed, cases in which the soft parts are completely torn away from the bone, leaving nothing but the latter, so that on the one hand no cicatrization could take place; on the other the extremity,

even if healing were to take place after months or years, would be absolutely useless; thus it is better to remove it at once. Moreover, complete detachment of the skin alone from the greater part of an extremity may, in rare cases, render amputation necessary, as in the following case:—A little girl, about ten years old, had her right hand caught between the rollers of a spinning machine; she forcibly drew back her arm, so that the entire limb might not be destroyed. The hand again made its appearance, but the skin from the tips of the fingers to the wrist remained between the rollers. The skin was torn all around the wrist, and it now came off like a glove. When the patient was brought to the hospital, the injured hand looked like an anatomical dissection; we could see the tendons work in their sheaths, when extension and flexion movements (which were in no way interfered with) were made; no joint was opened, no bone broken—what was to be done? A fairly large experience of such machinery accidents had taught me that fingers which have been entirely deprived of their skin almost invariably become gangrenous: thus we should have had an extraordinary stump of a hand which, under the most favorable circumstances, would have been nothing more than an unwieldy cicatrized stump; it was doubtful, indeed, whether a permanent cicatrix would have formed at all, and several months would have been necessary to obtain even this doubtful result. Under such circumstances it was better to do an amputation above the wrist at once, and this was done. Four weeks later the child left the hospital and was sent home; her employer provided an artificial hand with some simple mechanism, in order to compensate her, as far as he could, for the injury she had sustained.

Fortunately such cases are rare. In similar injuries of single fingers we mostly leave the process to itself, so that no more is lost than that which is absolutely incapable of living. We must always remember this principle in the surgery of the hand, that every inch—every line, more or less—is of great importance, and that single fingers, and especially the thumb if it be at all possible, must be preserved, for such fingers, if only partially movable, are infinitely more useful than the most elaborate artificial hand that can be made. With regard to the foot and the lower extremity other considerations have to be taken into account; of these we shall speak again when we come to the subject of compound fractures.

Still it would be a happy thing if these sad mutilations and the

slow healing were the only dangers which beset patients with contused wounds! Unfortunately there is a whole string of local and general complications which directly or indirectly endanger life! We will here refer to those complications which may be called local, and reserve the general ones for a separate chapter.

Considerable danger may arise from the possible infection of the healthy surrounding tissues by the decomposing products of the wound. Putrescent matters act as ferments on other organic combinations, especially on fluids wherein they are contained; they bring about decomposition more quickly than it would ensue spontaneously. You may almost wonder why extensive decomposition of parts which have been injured, but not actually destroyed, does not more frequently occur. In most cases, however, coagulation and adhesion of the soft parts and regenerative cell reaction set in so quickly along the borders of the living tissue, that a sort of living wall is formed by these means, which acts as a barrier to the passage of the putrid matter; the granulation surface also when once formed is particularly resistent to such influences. In many places a popular remedy is to apply cowdung and other dirty substances to ulcers; this scarcely ever causes any extensive putrefaction or granulating wounds. But if you apply these substances to fresh wounds, and bind them on in such a manner that the tissue becomes mechanically impregnated with the putrid material, the wounds will in many cases become gangrenous even to some depth down, and then finally an energetic and vital cell-proliferation opposes itself to the putrefactive ferment.

The reason why putrid substances act so detrimentally on fresh wounds, and scarcely at all on granulating wounds, is, I imagine, to be found partly in the gelatinoid nature of the granulation tissue, which is often several millimètres thick, and partly in the fact that putrid substances are chiefly absorbed by the lymphatic system. Thus, if you inject one drachm of putrid fluid into the subcutaneous tissue of a dog, you will produce inflammation, fever, and septicæmia; but if, having first produced a large granulating surface, you daily apply to it lint soaked in stinking pus, you will scarcely get any visible results at all. Putrid fluids can no doubt get into the veins and capillaries through the walls of these vessels, but experience teaches us that septic wounds are accompanied by lymphangitis more frequently than by phlebitis. I shall again refer to this point.

The more the tissues are saturated with fluid, and the more their vital activity is interfered with by a contusion, so much the more will they, on account of their lowered vitality, be disposed to putrefaction. The cases, therefore, in which great œdematous swelling supervenes after contusion are more dangerous in this respect. This œdema readily comes on, because laceration and contusion often intercept the venous and lymphatic circulation far beyond the limits of the wound. For example, a forearm caught beneath a stone weighing several hundredweight; probably there is only a small skin-wound, but yet the muscles are extensively smashed, and there is contusion of the tendons and fasciæ of the whole of the forearm, contusion and laceration of most of the veins; great œdematous swelling will quickly set in, because the blood is being driven through the arteries into the capillaries with additional energy. Great indeed will be the disturbance in the circulation and in the whole course of nutrition! It must soon become evident where the blood can still circulate and where not. At the wound there commences first a decomposition of the dead parts, this passes on to the stagnant humours, and, under unfavorable circumstances, spreads more and more, the whole extremity as far as the shoulder swells tremendously, the skin becomes red and shining, tense, painful, and covered with blisters, for beneath the epidermis also serum exudes from the capillary vessels of the skin. All these phenomena usually develop themselves on the third day after the injury, frequently with frightful rapidity. The whole of the extremity may become gangrenous in consequence of this disturbance of the circulation. In other cases, only the fasciæ, tendons and shreds of skin perish, whilst cellular infiltration of the whole of the connective tissue of the extremity (of the subcutaneous cellular tissue, the perimysium, the neurilemma, the sheaths of the vessels, the periosteum, &c.) follows, which leads to suppuration. Towards the sixth or eighth day the whole extremity may become thoroughly charged with pus already in a state of complete decomposition. Theoretically speaking, a cure is conceivable in such cases, *i. e.*, we might believe that the process could become arrested, and the pus and dead tissues come away through appropriate openings in the skin. But this seldom occurs in practice; if the state of things just described exist to the extent mentioned, nothing but speedy amputation can save the patient, and that not always. This kind of infiltration may be described as ichoro-serous; it is so at first only, soon becomes ichoro-sup-

purative, and finally entirely suppurative. Essentially, it is an inflammation of the cellular tissue resulting from a local septic infection, a *septic phlegmonous* inflammation, the products of which have a great tendency to decomposition which eventually leads, however, to extensive suppuration and necrosis of tissue in case the individual survives the blood infection always present under such circumstances. The earlier such processes become arrested, the more favorable the prognosis; the patient's danger increases with the advance of the local phenomena.

We must now refer once more to the arteries in cases of the coming away of dead portions of tissue. It may be the case that an artery is bruised in such a manner that its continuity is not exactly destroyed, and that the blood flows on through it, but a portion of its wall is dead and comes away from the sixth to the ninth day, or even later. Whenever this occurs, hæmorrhage will at once supervene proportionate to the size of the artery and the size of the opening. These *secondary hæmorrhages*, which generally occur suddenly, are extremely dangerous, because they affect the patient unexpectedly, sometimes during sleep, and not unfrequently are first noticed only after much blood has been lost. There is another way in which a late arterial secondary hæmorrhage may occur, viz. from suppuration of the thrombus, or of the wall of the artery; I observed one case of this latter kind in the third week after an important operation in the immediate neighbourhood of the femoral artery, close below Poupart's ligament, in which the artery, however, was not injured. The hæmorrhage, in this case, occurred in the night. As the wound had always looked healthy and the patient had for some time been sleeping the whole night, and we had been saying the day before that he might get up the next day, there was no nurse in the patient's private room; he awoke in the middle of the night of the twenty-second day after the operation, found himself swimming in blood and rang at once for the nurse, who immediately fetched the assistant-surgeon, who found the patient insensible already. He at once compressed the artery within the wound, and everything was done, while I was being fetched, to revive the patient. I found him pulseless and unconscious, but breathing, and the action of the heart could still be heard distinctly. While I was preparing to tie the femoral artery, the patient died; he had bled to death. A very melancholy case! An otherwise strong, healthy man, in the flower of his age, within a

short time of a cure, was doomed to lose his life in this miserable way. I have seldom been so depressed by any case! And yet no reproach could be made to any one; the circumstances had, as it happened, been very favorable; the nurse chanced to be awake in the adjoining room, the surgeon was only one story lower in the same house and in not more than three or four minutes at the bedside of the patient, but the hæmorrhage must have been going on for a considerable time before the patient awoke. He was only awakened by the moisture which he felt in the bed. The post-mortem showed that a small portion of the femoral artery had suppurated and become perforated. Fortunately, it is not always a femoral artery that bleeds, nor is the bleeding always so violent, neither does it always occur in the night; we need not, therefore, allow so rare a case of bad luck to destroy the interest we take in our art. Such arterial hæmorrhages usually commence to an unimportant extent from suppurating wound-cavities, and are soon checked by styptics or compression; but the hæmorrhage then recurs more violently after a few days, and is more difficult to arrest; eventually the bleedings are repeated more and more quickly, and the patient becomes more excited and more distressed.

In all cases of violent arterial secondary hæmorrhages immediate compression is the first remedy; every nurse, male or female, ought to know how to compress the arterial trunks of the extremities; these people, however, easily lose their heads, as in the case described above, and in their first anxiety run for the surgeon instead of compressing the artery themselves and sending some one else for him. Compression is here a palliative means only; it may happen that the hæmorrhage ceases therefrom; but if it be considerable, and you are sure where it comes from, I advise you strongly to tie the respective arterial trunk at once within the wound, or, if this cannot be done quickly, *in loco electionis,* for this is the only certain means. You must do this the more quickly if the patient be exhausted. Remember that a second or third such hæmorrhage will certainly cause death. On that account you must, in courses of operative surgery in the dissecting room, practise the tying of arteries before all other operations, so that you may become so expert therein as to be able to perform this operation when half asleep. Precisely in such cases much harm is done by unnecessary loss of time in employing styptics, which, for the most part, act here only as palliatives, or not at all. The tying of an artery is a

trifle for one who has his anatomy in his head and has made good use of his time in the courses of operative surgery! Anatomy! gentlemen! anatomy! and once more anatomy! A human life often depends upon the certainty of your knowledge of that science.

While on the subject of secondary hæmorrhages, let us also speak here of *parenchymatous secondary hæmorrhages.* The blood issues from the granulations as from a sponge; we nowhere see a bleeding, spirting vessel; the whole surface bleeds, especially at each change of the dressing. This may depend upon many circumstances; very fragile, easily destroyed granulations, in other words, faulty organisation of the same, may be the cause, and this faulty organisation of the granulations may again have its origin in a generally diseased condition of the whole organism (bleeders' disease, scurvy, septic or pyæmic infection). Local causes in the vicinity of the wound may also exist, *e. g.* if extensive, slowly formed coagula of blood occur in the secondary veins, the circulation in the vessels of the granulations would be so much interfered with, the blood-pressure so much increased, that not only would serum perhaps exude from them, but also ruptures of vessels take place. It is true that I have not yet had an opportunity of verifying this by post-mortem examinations, but I have seen only few cases of such parenchymatous secondary hæmorrhages. The last explanation sounds very plausible; it originated, so far as I know, with Stromeyer, who calls such hæmorrhages "phlebo-static." According to their origin it may be more or less difficult to arrest such hæmorrhages; in most cases, ice, compression, styptics will be expedient here; in more serious cases, the tying of the arterial branch, although this has sometimes failed. This kind of hæmorrhage mostly occurs in individuals much reduced by suppuration and fever, and is, therefore, an evil omen as to the general condition of the patient.

LECTURE XIII.

Advancing suppurations originating in contused wounds.—Secondary inflammations of wounds; their causes; local infection.—Febrile reaction in contused wounds, secondary fever, suppurative fever, fever-rigors, their causes.—Treatment of contused wounds; immersion, ice-bladders, irrigation; critique of these methods of treatment.—Incisions, counter-openings.—Drainage.—Cataplasms.—Open treatment of wounds.—Lister's method.—Prophylaxis against secondary inflammations.—Internal treatment of the severely wounded.—Quinine.—Opium.—Lacerated wounds, subcutaneous tearing of muscles and tendons, tearing out of limbs.

The granulating surface formed in a contused wound is, for the most part, very irregular, and often presents many corners and pockets; the contused wound does not suppurate on its surface only, but also the surrounding contused parts suppurate. The skin in the vicinity of the wound will often be found to be undermined by pus. The inflammation and suppuration often spread unexpectedly between the muscles, along the bones, and in the sheaths of the tendons, perhaps because the pus formed is absorbed by the lymphatic vessels, then decomposed, and thus causes fresh inflammation. Fortunately, such processes not unfrequently become arrested at the end of the second or third week, but the advance of the destructive process of suppuration may continue; it creeps on in the continuity of the sheaths of the tendons and of the cellular tissue; fresh nests of suppuration show themselves sometimes at one point, sometimes at another, the injured part continues swollen, œdematous, the granulations are of a dirty yellow colour, puffy, spongy. If we make pressure in the vicinity of the wound, pus flows slowly out of smaller or larger openings which have formed themselves spontaneously, and this pus, which stagnates in the depths of the wound,

is not unfrequently thin and ill-smelling. If this process continue long, the patient becomes weaker and more distressed, and has high and continuous fever; a wound which appears unimportant at first, in the neighbourhood of the hand, perhaps, may have caused frightful swelling and a very unfavorable general condition of the patient. It is in the sheaths of the tendons in the neighbourhood of the hand and foot especially that deep, insidious suppurations spread further and further, from which the inflammation may extend to the joint of the hand or foot, as, reversely, inflammations of the joints of the extremities easily extend to the sheaths of the tendons. These conditions may take a very unfavorable turn and must be most carefully watched. From continuous fever, as well as from considerable daily formation of pus, the strongest men may become frightfully emaciated in a few weeks, and die with symptoms of febrile marasmus.

We are now acquainted with two forms of inflammation which may supervene upon contused wounds:—1st, rapidly progressive septic inflammation of the cellular tissue, which occurs in the wound in the course of the first three or four days, (rarely within twenty-four hours after the injury, and equally rarely after the fourth day), and which is partly the immediate result of the injury, and depends partly upon local infection by decomposing humours and decomposition-ferments which develop themselves in the decaying tissues on the surface of the wound; 2nd, progressive, suppurative inflammation of the cellular tissue, which, especially in wounds of the hands and feet, may supervene from necrotic shreds of tissue during the cleansing of the wound, while the pus is not ichorous, although butyric acid is not unfrequently formed in it and gives it a bad odour.

Now, if the wound is already thoroughly cleansed and granulation has commenced, if the inflammatory process has become circumscribed, and the wound is beginning to cicatrise, you will, perhaps, think that nothing more can go wrong with it. But such is, unfortunately, not the case; fresh inflammation, followed by serious consequences, *may* set in. These *secondary progressive inflammations in and near suppurating wounds*, occurring later on and even several weeks after the injury, sometimes as unexpectedly as a flash of lightning from a clear sky, are of great importance and often highly dangerous; they have almost always a suppurative character and may, just as frequently as the primary progressive suppurations,

prove fatal by very intense, phlogistic, suppurative general infection, in many cases also by the dangerous nature of their site, especially in wounds of the head. These cases have something so striking, so tragical about them as to call for our special attention. Assume that you have brought a case of severe contusion of the leg, with fracture, successfully through the first dangers: the patient is free from fever, the wound is granulating very well, and even beginning to cicatrise. Suddenly, in the fourth week, the wound begins to swell, the granulations become croupous, finally infiltrated with fibrin (diphtheritic), the pus thin, the whole extremity swells, the patient has again high fever, perhaps with repeated rigors. These phenomena may disappear and everything return to the normal groove, but the result is often bad; in a few days, the strongest, healthiest man may become a corpse.

I saw a case of this kind in Zurich in the person of a brother officer wounded in the head; it may serve as a warning example. This youth received a sabre cut on the left side of the head; the bone was injured quite superficially; the wound healed quickly by the first intention, only a small spot continuing to suppurate. As the patient felt quite well, he paid no attention to the small wound, went out, and regarded himself as being in perfect health. Suddenly, in the fourth week, he had severe headache and fever after a walk. On the following day, about a teaspoonful of pus was found to have collected beneath the cicatrix, and let out by an incision. This had not the hoped-for good effect upon his general condition, the fever continued, delirium, followed by sopor, set in in the evening, and on the fourth day this fine young man was dead. It was easy to diagnose that suppurative meningitis existed here, and this was confirmed at the post mortem. Although the bone at the point exposed of the size of a pea, which had so long kept up a slight suppuration, was but little discoloured by an inconsiderable suppurative infiltration, yet the suppuration upon, in, and beneath the dura mater was decidedly greatest at the point corresponding to the wound, so that the fresh inflammation had undoubtedly proceeded from the wound. I saw a perfectly similar case, which also terminated fatally, a short time ago here in Vienna, in private practice, in a man who had received an apparently unimportant injury high up on the forehead, near the roots of the hair, from splinters of a soda-water bottle which had burst. He had been quite well up to six days before his death, and had attended to his business.

The inflammations which occur under such circumstances have generally, as already remarked, a diffused suppurative character, but other forms supervene or occur independently, viz., an ulcerative, diphtheritic form of inflammation of the skin, or *hospital gangrene*, or inflammation of the trunks of the lymphatic vessels (*lymphangoitis*), and a specific form of capillary lymphangoitis of the skin, also *erysipelas* or *erysipelatous inflammation*, lastly also inflammation of the veins (*phlebitis*). All these processes may not unfrequently be observed mixed with each other. We shall study these diseases more closely later on when speaking of incidental wound-diseases. But we must occupy ourselves here with the *causes* of the already-mentioned secondary inflammations before we pass on to the treatment of contused wounds, though we of course anticipate somewhat by so doing. All these forms of inflammation and also their reactions upon the organism are so closely connected with each other that it is impossible to speak of one set without mentioning the other.

As *causes* of the secondary inflammations in and around suppurating wounds during the healing process we may mention the following:—1. *Intense congestion at the wound*, which may arise from a violent movement of the injured part, or from violent general exertion, or from exciting drinks, intense emotion, in short, from everything which causes violent excitement. Such congestions are very specially dangerous in cases of wounds of the head. Hyperæmia from obstructions, *e. g.* from too tight dressings, may similarly be very detrimental. 2. *Taking cold locally or generally*. Of taking cold as a phlogogenic principle we know scarcely anything beyond the simple fact that, under certain circumstances not easily to be defined more exactly, a sudden change of temperature causes inflammations, especially at a *locus minoris resistentiæ* in an individual; in a wounded individual the wound is always to be regarded as a so-called *locus minoris resistentiæ*. The danger of taking cold in wounded persons was no doubt much over-estimated formerly, but I cannot quote distinct instances thereof. 3. *Mechanical irritation of the wound*. This is of great importance. Healthy, non-irritating, undecomposed pus of a wound is never absorbed by uninjured granulations, but if the granulations are destroyed by mechanical manipulations, *e. g.* by unskilful dressings, many probings, and such like manœuvres, in consequence of which the wound always bleeds afresh, fresh inflammations may be occasioned thereby. Any foreign bodies remaining in the wound also play an

important part, *e.g.* fragments of glass, sharp pieces of lead or iron, sharp splinters of bone; for the first processes which occur in the wound (septic phlegmonous inflammation, primary gangrene), the presence of such foreign bodies is of less consequence, but if, partly from muscular movements, partly from the movements communicated to the tissues by the arteries, the sharp edges of a foreign body are made to rub constantly against the tissues, violent inflammation occurs after some time. 4. *Chemical ferment-like irritations of wounds*, amongst which I may mention first soft foreign bodies, *e. g.* pieces of cloth, paper wads, which enter the tissues in shot-wounds; these substances become impregnated with the wound-secretions, in combination with which the organic substances (paper, wool, &c.) become decomposed and then act directly in the wound as irritants or ferments. I am inclined to think that the necrotic splinters of bone act deleteriously chemically rather than mechanically; they always contain in the Haversian canals or in the medulla some decomposing organic substances; all such necrotic fragments of bone have an ichorous smell if we extract them; if the surrounding granulations become partially injured by the sharp edges of such a fragment of bone, the ichor from it enters the opened lymphatic vessels or perhaps also the blood-vessels, and thus excites not only local but also and at the same time general infection. Necrotic shreds of tendons and fascia in the deep parts of suppurating wounds may be followed by the same consequences, although this happens more rarely.

Rare cases are met with, especially in hospitals, in which we are unable to recognise *any* of the above-mentioned causes; such occurrences then naturally excite unusual alarm, and it has been sought to explain them by an especially deleterious action of the hospital air, especially of such as is charged with the smell of pus. There are many reasons for doubting that the deleterious substances are in a gaseous form; if the ventilation be good, the air in the hospital may be kept pure, and yet this does not prevent the evil consequences in question; neither can we produce inflammations by any of the gases developed from pus or decomposing substances, except perhaps by sulphuretted hydrogen when taken up by water and injected into the subcutaneous cellular tissue. Putrid fluids and pus are not likely to be taken intentionally from one patient and placed upon the wounds of another. That the neighbourhood of a wound may, under certain circumstances, be infected

by the pus of the wound and a fresh inflammation produced, has been mentioned above. There scarcely remains anything left us, therefore, except to assume that the substances thus acting deleteriously are dry and in the form of dust; they may, indeed, float in the air of the hospital, or they may exist in the dressings, the lint, or the compresses used for dressing the wounds, or on the forceps, sounds and sponges brought into contact with the wounds.

Can it be fungi or any other organic germs of a nature hitherto inscrutable? This is, indeed, possible, for every cubic foot of air occasionally contains a quantity of such organic germs, and in a hospital especially, such germs of organic beings of an animal or a vegetable nature may be developed and fixed in wound-secretions, sputæ, excrements, and vessels containing urine, the more so the more such easily decomposing secretions and excretions are allowed to accumulate in ill-arranged privies, &c. For the present we must be content with conjectures on this point. We can, on the other hand, experiment with dried putrid substances and dried pus, by reducing them to a fine powder and introducing them into the healthy tissues of animals. Such experiments have been made by O. Weber and me, and it has been shown by them that animal as well as vegetable putrid dried substances, and also dried pus, act phlogogenically under certain conditions; if we pulverise these substances, stir them quickly with a little water, and inject them into the subcutaneous cellular tissue of animals, we thereby cause progressive inflammations just as with decomposing fluids and pus. That in a hospital such deleterious bodies in the form of dust may exist in the dressings, bedclothes, and perhaps on instruments, must, *à priori*, be admitted. In short, *it is possible* that the direct deleterious effect of hospital air on many wounds depends upon the circumstance that very fine putrid or purulent matters in the form of dust adheres to the dressing materials, or instruments, and that in them the ferments are contained.

That deleterious, infectious matters may also enter the body otherwise than through wounds, especially through the lungs, cannot be doubted; we explain to ourselves thereby, in fact, the origin of all infectious diseases, that substances find their way into the organism which act as organic poisons upon the blood and upon the whole organism; but whether these disease-elements which cause the infectious diseases occurring chiefly in the wounded enter the

organism otherwise than through the wound is a question the answer to which must depend very much upon the particular interpretation of the cases observed. We will return to this subject later on, in connection with incidental wound-diseases.

You will probably believe that you have caught me contradicting myself as I told you in yesterday's lecture that no molecular bodies enter the tissues through uninjured granulating surfaces. I must still assert this as holding good in ordinary cases; a healthy, uninjured, granulating surface is an essential defence against infection through the wound. But if the infectious matter itself is extremely irritating, so that the granulating surface is destroyed thereby and decays, a way is thus opened for the entrance of the poison into the tissues. More than this! there are certain matters which may be introduced from the pus-cells into the granulation-tissue, and perhaps still further. Strew the granulating surface in a dog with finely-powdered carmine, and some of the cells will take up the fine granules of carmine and enter with it into the substance of the granulations; after some time, you find cells with carmine in the granulation-tissue. I regard this as an abnormal retrograde movement of the pus-cells, concerning which we may otherwise assume that they advance from the granulation-tissue to the surface of the wound; of course no one has seen this. In any case, however, the above experiment serves to explain that molecular bodies also *can* penetrate from without into the tissues of the edges of wounds, and when these matters are sharply decomposing or corrosive, or contain in themselves phlogogenic poisons, they will cause violent inflammation. These considerations will render you very anxious concerning the fate of the wounded, for an absolute defence against such dangers appears unattainable. But I must here at once remark for your consolation that not all the molecular organisms which are contained in the atmosphere by milliards flourish on wounds, and that they are not all phlogogenic. In my opinion, not every micrococcus acts phlogogenically as such, but only those which originated in certain products of inflammation in decomposing pus, in putrid urine, in decomposing-tissue fluids, and there took up the ferment. This, it is true, is the most common form of micrococcus which occurs in hospitals, and especial energy is, therefore, called for to prevent their development in such institutions. How this is to be effected will be stated further on.

Febrile reaction in contused wounds is generally more violent

than in incised wounds; this is, according to our assumption, explained by the fact that, in consequence of the decomposition which takes place to a much greater extent in contused than in incised parts, more products of such decomposition find their way into the blood. If the phlogistic and putrid poison possess especially intense qualities in a given case, or if an unusual quantity of it be taken up (particularly in diffused septic inflammations), then the fever assumes the character of the so-called *putrid fever;* the state of things brought about in this manner is called *septæmia;* we shall occupy ourselves therewith more fully later on.

If the inflammatory process becomes progressively suppurative from the wound onwards, a correspondingly persistent inflammatory or suppurative fever will be kept up; such a fever has the character of a *febris remittens,* or in more severe cases, of a *febris continua remittens,* with very steep curves and occasional exacerbations, which are for the most part dependent upon progressions of the inflammation, or upon circumstances which facilitate the absorption of pus. If we speak of the fever which frequently accompanies the circumscribed traumatic inflammation, or perhaps *must always accompany it,* as simple *wound-fever,* we may call the later occurring fever "*secondary fever,*" or "*suppuration-fever.*" Such a fever may become associated immediately with the wound-fever, if the inflammatory process become at once progressive; but the wound-fever may have ceased entirely, the wound may have begun to heal, and if secondary inflammations such as we have just discussed in detail now attack the wound, fresh suppuration-fever is always combined with these; in short, inflammation and fever here always run parallel to each other. The fever, it is true, sometimes *appears* to precede the secondary inflammation, but this often results therefrom that the first and perhaps extremely slight changes in the wound have escaped observation. At all events, we must see the urgent necessity, on every fresh febrile movement which we observe in the patient, of searching for the inflammation-nest which may be the cause of it. Far be it from me to assert that it is necessary to measure the temperature of all the wounded; every surgeon experienced in the observation of patients will undoubtedly know how it stands with his patient without measuring the temperature, just as an experienced physician can diagnose pneumonia without auscultation and percussion; but, that taking the temperature is, under certain circumstances, a great aid in diagnosis and prognosis, no one doubts

who has acquired a fitting knowledge of the import of the temperature of the body. It stands therewith as with every other aid to observation; it is not difficult to detect dulness on percussion at a part of the chest where it ought not to exist, but to recognise the value of this dulness correctly in a given case is a thing that must be learnt; the same holds good also for observations of the temperature; we must learn, for instance, to recognise whether a low temperature in the case before us means good or evil.

Experiences teaches us that *secondary fevers* are frequently much more intense than the primary wound-fever; while it very rarely indeed happens that the wound-fever commences with rigors—slight shivering after great losses of blood and violent shocks is not usually accompanied by an increase of temperature—a secondary fever by no means unfrequently commences with severe rigors. We will here examine more closely this peculiar phenomenon. Rigors have always been regarded as a symptom essentially dependent upon blood-poisoning; if we now conceive of fever in general as a state of intoxication, we must seek for some special cause of rigors. Observation shows that the rigors of fever, which are always followed first by heat and then by sweating, are always associated with a *very rapid* rise of temperature, and if we examine by the thermometer the blood-temperature of a patient during such rigors, we find that it is high and rises rapidly. The blood is driven out of the vessels of the surface into the internal organs, and Traube, as already remarked, attributes to this the abnormal febrile rise of the temperature of the blood. We will leave this an open question for the present, but, in any case, there occurs so great a difference between the temperature of the air and that of the body that the patient experiences a feeling of cold. If you draw off the bed-clothes of a fever patient who is lying wrapped up in bed and does not feel cold, he will at once begin to shiver and tremble. A man has a kind of conscious feeling for the state of equilibrium in which the temperature of his body stands to the temperature of the surrounding air; if the latter be raised quickly he immediately feels more warmth, if it be lowered quickly he at once begins to shiver and tremble. This trival fact leads us to a further observation; this sensibility to warmth and cold, this conscious feeling of differences of temperature, differs greatly in individuals; it may also be greatly increased or diminished by the mode of life; some persons always feel too hot, others always too cold, while to others

the temperature of the air is very much a matter of indifference. The nervous system plays a great part here. More minute studies by Traube and Jochmann have, in fact, shown that the nervous excitability of the individual contributes greatly thereto to determine whether, with a rapid increase in the temperature of the blood, the change is felt very intensely or not, that, therefore, in torpid individuals or in comatose conditions, rigors do not so readily occur in fever as they do in excitable persons already weakened by long-standing disease. I cannot do otherwise than confirm this from my own observations.

Now if I am convinced in a general way that rapid increase of temperature accompanied by rigors occurs mostly where there is a sufficient degree of irritability if a considerable quantity of pyrogenic material is introduced suddenly into the blood, I am by no means prepared to deny that the quality of such pyrogenic material also enters into the question. Of this quality we know nothing chemically, but we can assume differences in it therefrom that not only the febrile symptoms but also their duration often differ so much that this cannot depend solely upon differences of power of resistance in the patient. According to my observations, absorption of pus and of perfectly fresh products of inflammation disposes much more to rigors than absorption of ichor, which otherwise acts much more dangerously and as a stronger poison.

I do not wish to tire you with too many questions of this kind, and will, therefore, return to the subject in the section which refers to general incidental wound-diseases and diseases of inflammation, which you may regard as the continuation of these reflections upon fever. I will only observe further that septic as well as suppurative primary and secondary inflammations may occur with incised wounds also, especially with greater operation-wounds, (after amputations and resections). If we have included the discussion of these conditions with contused wounds, this has been done because the latter much more frequently become complicated in the manner described than ordinary incised wounds.

Let us now direct our attention to the *treatment of contused wounds*.

A contused wound requires, in very many cases, no further treatment than an incised wound; the conditions for healing without artificial aid are present in both cases. All that is required in the case of a contused wound is to obviate from the first, if possible,

incidental damaging conditions, or at least so to control them that they shall not become dangerous. We can do something in both respects.

It has always been assumed, and that correctly, that the air with its oxygen and its ferments very especially facilitates the decomposition of dead organic substances and therefore also of contused parts; to act preventively in this respect means, to close the wound against the air and, for the purpose of avoiding warmth also as a promoter of decomposition, to place the injured part in a cold temperature. We attain both these objects simultaneously if we place the injured parts in a vessel containing cold water, the temperature of which we can regulate by adding pieces of ice as required. This treatment is called "immersion" or the "cold continuous water-bath;" I first saw it employed with excellent results by my earliest surgical teacher Baum, in Göttingen; it is only really applicable for the extremities, for the leg as far as the knee, for the arm somewhat above the elbow. A suitable arm- or foot-pan filled with cold water is placed in the patient's bed and the injured extremity is left constantly day and night therein. The patient must be placed in such a position that he can lie quite comfortably, and that the limb is nowhere pressed upon by the edge of the pan; this is easily done, and you may see such apparatuses in my clinique. For injuries of the hand, which are the most frequent, a mug with cold water suffices in private practice.

For parts which we cannot keep in this simple way in cold water, we seek to prevent the access of atmospheric air by putting on moist linen compresses, which may easily be adapted to the injured part; upon these is placed an india-rubber bag, (or in place of this a pig's bladder), filled with ice, which is to be renewed as the ice melts. It is still more effectual *to pack a limb completely in ice* in a pan, after wrapping it up in thick folds of linen. A third method of applying cold water is the so-called *irrigation*. For this, special apparatuses are required; the injured extremity is placed in a tin trough which has an escape pipe. Above the limb an apparatus is fixed from which cold water drops continuously from a moderate height upon it. Lastly, we may simply cover the wound from time to time with fresh compresses which have been dipped into iced water.

I have become familiar with all these modes of treatment in practice; not one of them acts with certainty prophylactically in

my opinion; in contused wounds of the hands and feet, the water-bath is the most effectual, since extensive after-suppurations very rarely occur with it. If we would obtain the same favorable results with the ice treatment, we must cover not only the wound but also the whole neighbourhood of it with ice bladders, *i. e.* pack it in ice. With the use of cold compresses we shall only produce sufficient cold effect by renewing them every five minutes, for they become warm very quickly, and the usual treatment with cold applications means but little more than keeping the surface of the wound moist; this is, therefore, strictly speaking, not a special mode of treatment, but the majority of small contused wounds heal spontaneously in this way, as I have already remarked, without being brought by cold under unnatural conditions. Irrigation is not a bad mode of treatment, but very troublesome, and it is frequently very difficult to prevent the bed from becoming wet with it; the behaviour of the wound does not differ in its further course from that with the more simple immersion, or ice treatment, so that I have not taken occasion to occupy myself further with irrigation. In France this method is employed by many Paris surgeons and held in great esteem.

I have still some special observations to make concerning the water-bath, since we are leaving entirely out of the question here wounds of bones and joints. I know of no contra-indication for contused wounds of the hand, forearm, foot, or leg; in the majority of cases the hæmorrhage is so slight in these injuries, and so soon ceases of itself, that the patient may very soon, often immediately after the injury, immerse the limb in cold water without there being any danger that hæmorrhage will occur; but the blood adhering to the injured part must be removed previously, the water itself be perfectly clear and transparent, and if it become turbid from the wound secretions must be kept clear by being changed frequently. Also if the injury be of two or even three days' standing, the water bath may still be employed with advantage; after this it is of little use. If the patients lie conveniently in bed with the pans, they are more content and freer from pain with this treatment than with any other. As regards the *temperature* of the water, it may vary greatly without producing any considerable change in the state of the wound; only the ice temperature and the very high temperatures attainable with poultices produce a somewhat different appearance of the wound. With temperatures from 54·5°

to 93·75° and 99·5° the wound presents no difference of appearance; perhaps at the higher temperatures suppuration is set up *somewhat* more rapidly, but the difference is certainly very slight. It follows from this that we may adapt the temperature to the wish of the patient. On an average, patients at first prefer a cooler temperature (54·5° to 66·75°), later on a warmer one (87·5° to 95°), but there are patients who complain of shiverings on the first day if the temperature of the water sink below 66·75°. We see from this that it is not of much importance whether we employ the so-called *warm* or *cold* water-bath. In some individuals an inconvenience arises on the third or fourth day which renders immersion unbearable to a few of them, viz. the strong swelling of the epidermis of the hand or foot, and the sensations of tension and burning which accompany it and somewhat resemble the effect of a blister; the thicker and more callous the epidermis was, the greater this inconvenience becomes, but it may be prevented by rubbing the injured hand with oil before placing it in the water, and by throwing into the water a handful of salt, which does no harm to the wound.

One important question is: how long shall the continuous immersion be employed? Only by the aid of a pretty extensive experience can one lay down rules for this. I have found that from eight to twelve days of continuous immersion suffice. After that time the limb is no longer kept in the water during the night, but is wrapped in a wet cloth, over which oiled silk is placed and kept in position; a few days later, this latter treatment suffices also during the day, while the water-bath is used morning and evening, or in the morning only, that the wound may be bathed and cleansed for half an hour or an hour. Finally, we discard the water altogether and treat the granulating, cicatrising wound according to the simple rules already laid down.

The changes which take place with this treatment of the wound differ somewhat from those described previously; in the first place, everything goes on much more slowly; it sometimes happens, especially with the cold water-bath treatment, that the contused wound looks as fresh after four or five days as if it had been made quite recently; we observe the same thing also for a considerable time with the treatment with bags of ice. This is not so remarkable as it at first appears, since experience has shown that the decomposition of organic matter proceeds more slowly in deep

water than in the air. Later on, the pus usually remains lying as a flaky, semi-coagulated layer upon the wound and must be washed or syringed off that we may see the granulations beneath it, which are often watery and rather pale. This examination is of great importance and saves us from illusions concerning the efficacy of the water-bath in cases of suppuration in deep cavities, for we might think that the pus would flow from the wound directly into the water and become diffused in it, so that it would only be necessary to place the suppurating part in the water to keep it clean. *The water-bath does not favour the escape of the pus at all, is, in fact, preventive of it;* the pus formed on the granulating surface or in the cavity coagulates at once in contact with the water and remains, for the most part, lying in the wound; washing or syringing is required for its removal; by the swelling of the granulations the escape of the pus from the deeper parts of the cavity is rendered altogether impossible. It follows from this that in cases with suppurating cavities the water-bath is of no value whatever, but rather does harm, and that a limb with a contused wound must be taken out of the water as soon as deep, progressive suppurations commence from the wound, but a temporary foot- or arm-bath for half an hour is not interdicted. If no progressive processes of suppuration are set up, and we leave the wounds two, three, or four weeks in the water, no especial harm will result therefrom, but the healing process will be very much protracted; the parts continue much swollen in the water, the granulations are watery (rendered œdematous artificially) and pale, while the cicatrisation and contraction of the wound does not commence. If you now take the limb out of the water the wound soon contracts, in a few days the granulating process appears stronger, the pus more healthy, and the healing process advances.

I must now say a few words concerning the continuous ice treatment I will assume that you have covered the contused wound at once with bags of ice. Here also you will find that the throwing off of the contused parts goes on very slowly and that no bad smell becomes developed in the wounds, unless large portions of tissue should become gangrenous. To prevent stench altogether, if possible, I first place upon the wound lint steeped in chlorine water and renew it frequently. If we continue this treatment for four or six weeks, all the necessary processes in the wound will go on slowly and sluggishly; in like manner also the cicatrisation and

contraction of the wound occurs very slowly under the influence of the ice, and this method will, therefore, be unsuitable wherever it is desired to expedite the definitive healing process. Most surgeons are of opinion that, by placing bags of ice upon the fresh wound, we can prevent violent inflammations. You will therefore find that, in the majority of contused wounds, ice is at once placed upon them. This is sometimes very acceptable to the patient because it relieves pain, but its prophylactically antiphlogistic effect is, in my opinion, very slight. For centuries already men have sought for such a remedy, as well as for a prophylactic in inflammations of internal organs. By the application of ice to fresh wounds we can neither prevent entirely ichoro-serous infiltration nor suppurative inflammations; such, at least, is my opinion! Many believe, as already remarked, in the prophylactic effect of ice, and are convinced that with this means alone they can save persons severely wounded. I have become convinced that the dangerous incidents affecting wounds not unfrequently occur in spite of ice and are often absent when ice is not used, although the nature of the injury would lead us to expect them.

We can by no means always succeed, with the aid of cold, in preventing the extension of the suppurations proceeding from wounds; sometimes the œdematous skin becomes more and more red and painful, and if you make pressure upon it, there flows sluggishly from some corners of the wound pus which is often thin and serous, but sometimes also tolerably consistent. Under such circumstances, an escape must be provided for the retained pus, especially if it be ill-smelling or ichorous, so that it may come away easily, and for this purpose it is often necessary to make pretty deep incisions in the soft parts, and to keep them open. When this must be done, how we can best set about it in individual cases, and where incisions must be made, all this you must observe and learn in the clinique. For sounding such suppurating cavities I prefer a slightly bent silver catheter, which I introduce from the wound to the bottom of the suppuration-canal, then press the point from below against the skin and there make the incision. For the extension of these so-called *counter-openings*, as well as of other wounds, a knife is used which is pretty long, straight or bent, and provided with a knob at the point (*Pott's* knife). These counter-openings should, in general, not exceed 0·8 inch in length, but when necessary, several of this length may be made; it is not

advisable, without urgent cause, to lay open the soft parts of the whole forearm or leg longitudinally, as was taught formerly, because the skin afterwards contracts so much that the healing of the wounds eventually requires an unusually long time. To prevent the new openings from closing up again quickly, which however seldom happens, you may draw a number of silk threads through the suppuration-canals, tie them together and leave them for a short time. Instead of these setons of silk threads or strips of linen, drainage-tubes of india rubber have been used recently, as mentioned above. When making such counter-openings, you will not unfrequently meet with dead tendons, or shreds of fascia, or foreign bodies. These must be removed.

Many of our former colleagues would have shaken their heads dubiously if they had heard that we had spoken so much at length of the treatment of contused wounds and secondary inflammations without saying anything about *poultices*. *Tempora mutantur!* Formerly, poultices belonged as certainly to suppuration wounds as a lid to a box, and now! years have passed in my wards in which poultice cakes have not once been applied to their original purpose! The employment of moist warmth, whether in the form of poultices, or of thick cloths steeped in warm water, is incapable of arresting the progress of suppurations in the cellular tissue; with long continued use of moist warmth, granulations assume a flabby appearance, the soft parts swell greatly, and the healing process is not promoted. Moreover, poultices can only act energetically as moist warmth when they are renewed frequently; the employment of them is troublesome; they readily become sour, and sometimes they are burnt, and the whole mess cannot be properly looked after in a hospital; one poultice, covered with pus, is taken off, fresh pulp is put in and often immediately used for another patient. In many hospitals, at least one half of the surgical patients have poultices; hundredweights of the various poultice-materials are consumed every month in the surgical wards. In my division they are almost entirely banished; I will give you, at the right moment, the cases in which we may still use them with advantage.

Little, therefore, as I can recommend the use of moist warmth as an ordinary mode of treatment of wounds, I still regard it as very suitable in all those forms in which an extensive, hard (fibrino-diphtheritic) infiltration of the cellular tissue exists. In these cases the moist warmth is not only agreeable to the patient, because it

renders the tense skin soft and pliable, but it also appears to favour the resolution of the coagulated products of inflammation, either because they may become absorbed, or because they must be thrown off with the necrotic tissues with copious suppuration. I employ, in such cases, wrapping up in warm, moist cloths, over which a waterproof covering is placed.

I have not said anything of the necessity of *absolute rest* for any injured part of the body; it may appear extraordinary to you that I should speak of this at all, as it would seem to be a matter of course. I attach very especial importance to it, for since deleterious substances may be taken up from the wound into the blood, every muscular movement in itself, as well as every congestion in the wound occasioned thereby, in short, everything which gives an impetus to the stream of the blood and lymph in the neighbourhood of the wound, may eventually prove detrimental.

Further, the *raised position* for the injured part is also not to be neglected when it is practicable. That gravitation plays an important part in the movement of the blood is easily proved; let one of your arms hang down loosely by your side, without any muscular tension, for about five minutes, and you will feel a distinct sense of weight in the hand, while the veins on the back of the hand will be seen to be much swelled; if, on the contrary, you keep the arm for some time raised in the air, the hand will become pale and thinner. So long as weakly persons remain in bed in a horizontal position, they will appear, for instance, much fuller in the face than if they had held the head upright during the day. For inflammations of the hand, Volkmann has recently recommended very strongly vertical suspension of the arm as a powerful antiphlogisticum; I also have employed this method in consequence thereof, and found it very efficacious in cases of inflammations of the skin, but for deep-seated inflammations of the wrist-joint it appears less useful.

Perhaps, in the future, the water-bath, the ice treatment, and poultices will fall more and more into the background in presence of the *open treatment* of wounds, from which I have seen very good results in contused wounds as well as in incised wounds with cavities, and in presence of the Lister method of treating wounds, about which all those are enthusiastic who have had frequent opportunities of employing it for contused wounds. The so-much dreaded access of air to the surface of a wound, even of the air in ill-ventilated hospital wards, is not, in my opinion, so deleterious

as dressings and sponges of doubtful cleanness. The assertion that air is detrimental to suppurating wounds rests mainly upon the observation that the access of air to the cavities of abscesses with rigid walls and to serous sacs generally causes an increase of the suppuration. Apart therefrom that in many of these cases it is by no means proved that it is always precisely the access of air which causes an exacerbation of the process of inflammation, the circumstance especially in fault is, that the air in suppurating cavities is warmed by the temperature of the body and charged with watery vapour from the pus. This confined air now becomes a regular breeding place for those minute organisms with the increase of which decomposition-ferment so rapidly increases, and which are, indeed, always contained in greater or less number in the air. Every observant housewife knows that pieces of meat hanging in a draught of air keep better than pieces of meat put into a cupboard and covered, even if the air in the latter is kept cool by ice. Air moving freely and becoming changed causes no inflammation in wounds; confined air is, no doubt, very dangerous. That a wound treated *from the first* by the open method has no bad smell, unless larger shreds become gangrenous in it, I have stated already; that is also the reason why flies do not make use of these open wounds for depositing their eggs upon them, while they readily creep into the dressing for that purpose. I must confess that I was very agreeably surprised by these observations, because I feared that the flies would render the open treatment of wounds in summer impossible. The longer I carry out the open treatment of wounds the more satisfied I am with it; you will yourselves have opportunities for convincing yourselves of this in my clinique. No method of treatment of wounds furnishes an absolute guarantee against incidental wound-diseases; each method must be studied. Thus, in the open treatment of wounds, superficial adhesions of individnal wound-pockets may take place, in which decompositions of secretion develop themselves; we must know how to recognise such conditions early and to obviate them.

Many surgeons now strongly advocate the method of the occlusion of wounds by thoroughly disinfected dressings and early introduction of drainage tubes to carry off the wound secretions, and by the application of antiseptic dressing-materials after the methodical instructions of Lister.

It is asserted that by this method an equally mild course is

obtained as in subcutaneous contused wounds, that the dead shreds of tissue do not become decomposed, but shrink up without stench and are thrown off with very little suppuration, that the clots of blood either become organised directly, or pass out of the wound in the form of inodorous, grey fragments, that acute septic, or progressive, suppurative inflammations never occur with it, and that the severe, incidental wound-diseases, of which we shall speak later on, never become developed with it. I cannot do otherwise than recommend strongly to you the employment of this method.

Generally speaking, I recommend you as well for the period of your studies as for your future practice to study and observe thoroughly *one* of the methods of treatment recommended to you, to master *one* thoroughly, and not to allow yourselves to become unsettled in your principles of treatment without strong cause, or to be led into too frequent change by every new fashion.

As regards the treatment of secondary inflammations, a careful prophylaxis is first of all to be recommended; avoidance of congestive states of the wound, of taking cold, of all mechanical or chemical irritation, and above all, careful avoidance of infection. What can be effected in the latter respect by ventilation and the proper use of disposable spaces in a hospital will be spoken of later on when we deal with incidental wound-diseases in general. For avoiding local infection of the wound by dressing-materials or instruments, the following must be borne in mind. We must be very careful about the dressing, the cleansing of the wound, and the choice of compresses, lint, and wadding; in this I can put up with any amount of pedantry; we must see to the greatest cleanliness in the mattresses, straw-bags, bed-clothes, oiled silk, in short, everything about the patient. The bleeding of the wound while the dressing is being applied is easily avoided by the new methods in use. We sprinkle all the parts of the dressing-material with a solution of chloride of lime, carbolic acid, or other antiseptics; for the removal of pus, sponges should never be used, nor, in operations, more than can be avoided; cleansing should be effected by syringing, or with wadding sprinkled with antiseptic solutions. If we are compelled to use sponges, we should take new ones and disinfect them at once with hypermanganate of potash or carbolic acid. In the chlorine water (equal parts of aqua chlori and water), or in the solution of chloride of lime (10 parts of chloride of lime dissolved in 500 parts of water and filtered), no organic bodies

subsist permanently at the ordinary temperature of a room, any more than in alcohol, lead-watee, the solution of acetate of alumina (alum 20 parts, acetate of lead 35 parts, water 400 parts, filter, according to Burow sen.), in salts of sulphuric acid (sulphate of soda 50 parts, glycerine 250 parts, water 450 parts), or the stronger solutions of hypermanganate of potash. Lister recommends carbolic acid as an especially efficacious antiseptic; it may be diluted with oil (5 per cent.), with glycerine or water (from 1 to 5 per cent.), and the carbolic oil may be made into a paste with scraped chalk, then spread upon tin-foil and the wound shut off from the air therewith. "Deodorising powder," *i. e.* coal tar mixed with sulphate of lime (gypsum bituminatum) strewed dry upon ichorous wounds, is a very useful preparation for wounds that are not too deep.

You must pay especial attention to the cleanliness of the instruments with which you touch the wounds, to the sounds, forceps, knives, scissors; everything must be wiped before the operation, or if suspicious, rubbed with cleansing powder. It requires the full, internal conviction of the necessity of all these precautions to induce us to take them. Lister's method gives distinct, detailed instructions on all these points.

If, in spite of every precaution, decomposition, gangrene, or phlegmonous inflammation occur in contused wounds, or in their vicinity, we must abandon the dressing with the protective immediately upon the wound. We must enlarge all the wound and pus cavities, and fill them up with pads of lint or wadding which have been steeped in a strong, antiseptic solution. After many experiments I always return to the use of acetate of alumina; it acts very energetically for drying up and deodorising, without replacing the ichorous smell by another equally disagreeable. It is true that the dirty blackish-grey colour which results from the formation of sulphuret of lead from the sulphuretted hydrogen of the ichorous pus and the lead contained in the antiseptic solution is an unpleasant but harmless concomitant. Until the acetate of alumina has thoroughly penetrated the mortified shreds of tissue, the dressing must be changed frequently, or the solution of the acetate poured every two hours upon the lint lying in the wound. When the wound begins to cleanse itself, dressing once a day suffices: upon simple, granulating wounds the acetate of alumina has too drying an effect and also causes irritation and pain. We then pass on to

dressings with the protective, and finally to dressings with simple ointment. After the acetate of alumina, solutions of chloride of lime act most powerfully, but since their antiseptic effect depends upon the development of chlorine alone, it is temporary only, and these dressings must be changed frequently to effect good deodorising or disinfecting results.

Glycerine is a very good disinfectant and acts extremely well if poured freely upon the dressing every two hours. If applied to wounds in large quantity from the first, it extracts so much water from the necrosed shreds of tissue that no foul smell arises; if decomposition has already set in, it acts very slowly as a deodoriser; after three or four days' free application, wounds often become so red and sensitive that the use of it must be stopped. Solutions of chloride of zinc are also recommended for washing out ichorous cavities; I have often found the superficial cauterising action to be very transient. Concentrated solutions of carbolic acid in oil or water (5 per cent. and more), frequently have a very acute, alarming, poisonous effect when applied to large surfaces, and are not so efficacious as acetate of alumina for deodorising and drying up necrosed tissue. I have had no experience of the antiseptic value of the salicylic acid recommended by Kolbe and Thiersch, or of the sulphate of soda so highly spoken of by Polli and Minnich.

Are we to prescribe for our patients in such cases anything beyond cooling drinks and medicines, regulation of the diet, &c.? The remitting fever not unfrequently accompanying such suppurations makes the patient languid, low-spirited, and often sleepless. Two remedies are here suitable: quinine and opiates—quinine as tonic and febrifuge, opium, and particularly morphia, as narcotic, especially in the evening, to procure rest during the night. I usually adopt the following plan with such patients. So long as there is little or no fever with progressive suppurations, I give nothing; if there is much fever towards the evening, I give in solution or powder during the afternoon, one or more doses of quinine (about $4\frac{1}{2}$ grains to the dose), and at bedtime gr. $\frac{3}{20}$ths—$\frac{6}{10}$ths of muriate of morphia or gr. $1\frac{1}{5}$th of opium. As soon as the fever ceases I omit these remedies. You should be especially sparing of the opium when it is not required, because it occasions constipation.

Yet a few words now concerning *lacerated wounds*. These are generally of less serious import than contused wounds, and that

because they are, for the most part, more observable, and we have no reason to fear that the injury extends deeper than we can recognise; we see how far and where the skin, muscles, nerves, and vessels are torn. Healing by the first intention may be tried and not unfrequently succeeds, while the edges of the wound are often viable; suppuration will, it is true, generally occur. But stop! not always are the lacerations exposed to view; there are also *subcutaneous ruptures* of muscles, tendons, and even of bones, although there has been no contusion. Some one wishes to jump over a ditch and takes the necessary run, but fails to get over, falls, feels severe pain in one leg, and limps with it. We examine him and find immediately above the tuberositas calcanei a hollow into which a thumb may be placed, the movements of the foot are imperfect, especially extension. What has happened? Through the violent muscular action the tendo Achillis has been torn away from the calcaneus. Something similar occurs with the tendon of the quadriceps femoris at its attachment to the patella, with the patella itself, which may be torn through in the middle, with the ligamentum patellæ, with the triceps brachii, which becomes torn away from the olecranon, and generally takes with it a piece of the latter. These are some examples of the subcutaneous rupture of tendons; I have seen subcutaneous rupture of the rectus abdominis muscle, vastus externus cruris, and other muscles.

Simple subcutaneous ruptures of muscles are not serious injuries; they are easily recognised by the disturbance of function and by the visible and still more palpable hollow which shows itself at once but afterwards becomes masked by the extravasation of blood. The treatment is simple: rest for the parts, which must be placed in such a position that the ruptured ends may be brought into contact by relaxation of the muscle, cold compresses, applications of solution of lead for some days; after eight or ten days the patients can generally get up again without pain. A band of connective tissue is formed at first, which soon becomes so thickened by shortening and shrinking that a firm, tendinous cicatrix is formed; the course is exactly the same as after the subcutaneous division of tendons, of which I shall speak later on in the chapter upon contractions.

Disturbance of function rarely results to any considerable extent, but there is sometimes a slight weakness in the limb and loss of the more delicate movements, especially in the hand.

FIG. 46.

FIG. 47.

FIG. 48.

FIG. 46.—Middle finger torn out with all its tendons.
FIG. 47.—Proximal end of brachial artery (torn through).
FIG. 48.—Arm torn out with scapula and clavicle.

To cause subcutaneous ruptures of muscles and tendons of this kind by crushing, powerful crushing forces would be required; such a contusion would probably run an unfavorable course; extensive suppurations and necrosis of the tendons might well be looked for. You see in this case also how different may be the course in injuries apparently similar, according to the manner in which they have been occasioned. In injuries by machinery there is often such a strange combination of contusion, twisting, and laceration, that a prognosis of the course of such cases is often very difficult even for a surgeon of great experience. Especially worthy of mention is the generally favorable course when smaller or even larger members are torn out, as *e. g.*, the hand. I have seen two cases of tearing out of fingers, one of which I will describe to you shortly:—A bricklayer was working upon a scaffolding and suddenly felt it fall from under him; from the roof of the house against which the scaffolding had stood hung down a loop of rope; the falling man caught hold of this, but only succeeded in seizing it within the loop with the middle finger of the right hand; he hung thus for a moment and then fell to the ground, but fortunately the distance was so short that he did not sustain any injury therefrom. He had lost the middle finger of the right hand, however, whieh had been torn out between the first phalanx and metacarpal bone, and left hanging in the rope. Attached to the finger were found the tendons of the two flexor and of the extensor muscles. The man dried the finger and tendons and afterwards carried it in his purse as a memento of the event. I saw a perfectly similar case in the clinique at Zurich (fig. 46). The healing process went on without any serious inflammation of the forearm, and did not really require any artificial help. I also saw two cases of evulsion of the hand in Zurich; in one of these sufficient skin was left to admit of spontaneous healing, in the other amputation of the forearm was necessary. Both cases terminated favorably.

It sometimes happens in war that arms and legs are torn away at the joints by large cannon-balls. I have also seen a case in a boy of fourteen in which the right arm was so completely torn away from the chest with the scapula and clavicle that it was only attached at the shoulder-joint by a bridge of skin two inches broad (fig. 48). The axillary artery did not give a drop of blood; the extremity was closed by torsion (fig. 47). The poor boy died soon after the injury. Evulsions of whole extremities are generally soon fatal; a

considerable number escape, however. A pupil of mine, Dr. Pernitza, railway surgeon in Vienna, recently showed me a powerful young man who had had the whole of one arm torn off with the clavicle but without the scapula; the healing process went on uninterruptedly.

LECTURE XIV.

CHAPTER V.

ON SIMPLE FRACTURES OF BONES.

Contusion and Concussion of Bones, various kinds of Fractures.—Symptoms, method of diagnosis.—Course and phenomena recognisable exteriorly.—Anatomical character of healing process and callus-formation.—Sources of the inflammatory process of ossification, histology.

Gentlemen,—We have hitherto occupied ourselves exclusively with injuries of the soft parts; it is time for us to pay some attention to the bones. You will find that the processes which nature establishes to attain here also, as far as possible, the *restitutio ad integrum,* are essentially the same as those with which you are already familiar. The circumstances are, however, more complicated, and can only become intelligible if we already fully understand the healing processes in the soft parts. Every layman knows, in a general way, that bones may be broken and become healed quite solidly; this can only happen by the aid of bony matter, as you can easily recognise *à priori,* and hence it follows, further, that bony tissue must be formed anew therefor; *the cicatrix in the bone generally consists of bone:* a very important fact, for if it were not so, if the fractured end only became united by connective-tissue, then would the long cylindrical bones especially not become firm enough to support the body, aud many persons would continue to be cripples for the rest of their lives in consequence of the simplest fractures. But before we follow the processes of the healing of bone into their minutest details—a study always prosecuted with great interest by surgeons—I must point out to you many things concerning the causes and symptoms of simple fractures of bone;

I say *"of simple or subcutaneous fracture of bone"* as contrasted with fractures complicated with wounds of the soft parts.

Man may come into the world with bones already broken; the bones of the fœtus may break in the womb either from abnormal contractions of the womb itself, or from blows or pushes during pregnancy, and such an intra-uterine fracture generally heals with considerable dislocation; the *vis medicatrix naturæ* is, as we shall also see on other occasions, more skilled in internal medicine than in surgery. Fractures of bone may naturally also occur at any age, but they are most frequent from twenty-five to sixty years of age, and that for the following reasons. The bones of children are still pliable and therefore do not break so easily; if a child falls, it does not fall heavily. Old people have, as it is expressed in ordinary language, brittle, friable bones, *i. e.*, anatomically speaking, at an advanced age the medullary canal becomes wider, the cortical substance thinner; but old people are seldom in danger of having their bones broken, because they are prevented by their want of strength from doing heavy or dangerous work. The age at which working men are compelled to undertake hard work is the period during which there is most frequent opportunity for injuries generally and especially for fractures. That fractures of bone occur so much less frequently in women than in men has its cause in the nature of the occupations of the two sexes, as it is easy to understand.

It likewise depends upon purely external circumstances that the long cylindrical bones of the extremities, especially those of the right side, break more frequently than the bones of the trunk. That diseased bones and such as are weak in themselves should break more easily than healthy bones is a matter of course; certain diseases of bones dispose to fracture, therefore, especially the so-called "English disease or rickets," which depends upon deficient deposition of salts of lime in the growing bones and occurs in children only; further, softening of the bones or "osteomalacia," which results from abnormal widening of the medullary canal and thinning of the cortical substance and which, when highly developed, is accompanied by perfect softness and pliability of the bones.

The two following are more special causes of fractures of bone:

1. External violence, the most frequent cause; the action may differ as follows: the force, *e. g.*, a blow or thrust, affects the bone in such a manner that the latter is crushed or split exactly at the

point of impact; here the force has caused the fracture *directly;* or the bone, especially if it be a cylindrical one, is bent beyond what its elasticity admits of, and breaks like a stick which is bent too much; here the force acted *indirectly* only upon the point of fracture. With the latter mechanism you may put in the place of the single cylindrical bone an entire extremity, or the vertebral column as a whole, regarding them as flexible to a certain extent, and carry over thereto the conception of the indirect effect of the force.

Let us take a few instances of this: if a heavy weight fall upon the forearm when at rest, the radius and ulna are broken by direct force; if a man fall upon his shoulder and his clavicle be broken obliquely at its middle, this fracture is caused by indirect force. In both these forms of injury there is generally contusion of the soft parts; in the latter case, however, more or less distant from the point of fracture, in the former, at the point of fracture itself, which is, of course, to be regarded as somewhat more unfavorable.

In a case of powerful direct action of force upon a bone it does not always follow that a fracture will be produced; it is in itself evident that a long series of injuries must exist, from contusion of the periosteum to complete crushing of the bone. Now, the periosteum was perhaps strongly crushed, or the bone was, at the time of the accident, also somewhat compressed, but recovered by its elasticity the normal shape, while the bony tissue was nowhere broken into. The medulla may here have been greatly contused. Lastly, slight injuries may have occurred to the spongy portion which are not always set right entirely, although the form of the cortical substance is not visibly changed. All these direct injuries to bones caused by strongly compressing forces are included under the name of *contusion of bones. Concussion of a bone* may be occasioned as well by direct as indirect force, and have as consequences lacerations of the medulla with extravasations of blood. Pain and disturbances of function will be more severe after these injuries than after injuries to the soft parts; a certain diagnosis of the degree of the force-effect can often be formed only from the further course of things. Concussions of bone with contusions, especially, *e.g.*, a fall upon the great trochanter, are often followed by long-continuing ostitis, which does not, indeed, often terminate in suppuration, but in the formation of osteophytes, sclerosis, and, in persons of advanced age, long-continued, sometimes permanent disturbance of function.

2. Muscular contraction may, although under rare circumstances, be the cause of fracture: as I pointed out to you already in connection with subcutaneous laceration of muscles, the patella, the olecranon, or a part of the calcaneus may be broken off by muscular contraction.

The manner in which bones break in these different applications of force is very varied, but some types exist with which you must become acquainted: firstly we may distinguish between incomplete and complete fractures. Amongst the *incomplete fractures* again we observe different forms: *fissures, i.e.* cracks, tears; these are most frequent in the flat bones, but are also met with in the cylindrical bones, especially as longitudinal fissures in connection with other fractures; the fissures may gape or appear like a simple crack in a glass. *Infraction*, or crooking, is a partial fracture, which generally occurs only in the very elastic, soft, and especially rachitic bones of children; you may most easily imitate this form by bending the shaft of a quill until the concave side of it gives way; in the clavicle also such partial fractures are not uncommon in children. What is understood by chipping off is also evident; knives belonging to machinery, sabre-cuts, &c., are the most frequent causes thereof. Lastly, the bone may be perforated although its continuity is not interrupted, as in a wound with a pointed instrument through the scapula, or a clean shot through the head of the humerus; the latter form of injury is usually called a *perforated fracture*.

In the case of *complete fractures* we speak of *transverse fractures, oblique fractures, longitudinal fractures, serrated fractures, simple* and *multiple fractures* of the same bone, and *comminuted* fractures: expressions which are all intelligible in themselves. Lastly, we must mention that in certain individuals, up to about the twentieth year, an interruption in the continuity of the cartilages of the epiphyses may occur, although this is very rare and the cylindrical bones much more readily break at another point.

It is often easy to recognise whether a bone is broken, and the diagnosis can be made with certainty by laymen; in other cases, the diagnosis may be very difficult, sometimes, indeed, we can only conclude upon the probability of a fracture.

Let us go through the *symptoms* briefly one after the other.

First of all accustom yourselves to begin by looking at every injured part closely and comparing it with the sound one; this is

especially important with the extremities. You may frequently recognise, by the mere observation of the injured extremity, what the injury is. You ask the patient how the injury occurred, causing him, meanwhile, to be undressed carefully, or if this gives too much pain, having the clothes and boots cut off, so that you may see the injured part plainly. The manner and force of the injury and the weight of the object which may have fallen upon the part will already give you an approximative idea of what you have to expect. If you find the extremity crooked, the thigh, for instance, bent convexly outwards and swollen, if livid spots show themselves at the same time beneath the skin, and the patient cannot move the limb without great pain, you may conclude with certainty that a fracture exists. You here require no further examination to establish the simple fact of the bony fracture and need not for that purpose put the patient to pain. But to ascertain the *position* and *direction* of the fracture, you must examine it with your hands. This is necessary less on account of the treatment to be adopted than to enable you to predict whether and how a cure may be effected.

In such a case you have formed your diagnosis at a glance, and it will often be easy for you in surgical practice thus to ascertain the true state of things if you accustom yourselves to a thinking use of your eyes, and if you acquire a certain readiness in judging of the normal outlines of the body. You must, nevertheless, understand quite clearly how you have come to this rapid diagnosis. The first thing was the nature of the injury, plus the deformity; the latter depends thereon that the two or more fragments of bone have got out of their right places. *This dislocation of the fragments* is the consequence, partly of the injury itself (the fragments are driven forwards in the direction communicated to them on the abnormal bending of the bone), partly of the muscular contraction which no longer acts upon the whole bone but upon a portion of it only; the muscles are excited to contract partly by the pain of the accident itself, partly by the sharp ends of broken bone; the upper broken end of the femur, for instance, is raised by the flexor muscles, the lower end drawn upwards by other muscles near or behind the upper broken end, and thus the thigh must appear shortened and deformed.

The *swelling* results from the *extravasation of blood* (we are speaking here of a quite recent fracture); the blood comes espe-

cially from the medullary canal of the bone, but also from the contused vessels, or such vessels of the surrounding soft parts as have been torn by the sharp ends of broken bone; it looks bluish through the skin when it has reached its under surface, which takes place gradually. The patient, as already stated, cannot move the limb without pain; the cause of this *disturbance of function* is self-evident. If you examine each of the above-mentioned symptoms in itself, not one of them alone, neither the manner of the injury, nor the deformity, nor the swelling, nor the extravasation of blood, nor the disturbance of function, gives singly the proof of a fracture, and yet the combination of them all is conclusive; you will frequently have to learn to diagnose them in practice.

All these symptoms may, however, be wanting, and yet a fracture exist. If we have an injury and none of the above-named symptoms are well developed, or only one or the other of them is plainly visible, manual examination must be brought to our aid. What do you propose to discover with your hands? Make yourselves quite clear on this point. How often have I seen young surgeons manipulate the injured parts with both hands, causing the patient intense pain, and yet gain no information by the examination. You may feel three things with your hands in fractures of bone: (1) *abnormal mobility*, the only, so to speak, pathognomonic sign of a fracture; with this you may very frequently recognise (2) the direction of the fracture, and sometimes whether there are more than two fragments; (3) you will frequently feel a rubbing and creaking between the fragments at every movement of them, the so-called "crepitation." To crepitate signifies, strictly speaking, to grate; that is a sound, and yet we say we feel crepitation; but you must not take offence at this, it is an abuse of the word, no doubt, but one which has been introduced so generally in practice that it can no longer be rectified, and every one knows what is to be understood by it. By means of a certain knack you may generally find out in a moment all that can be ascertained by palpation, and need not, therefore, torture the patient long. Crepitation may be wanting altogether, or be very indistinct; it naturally exists only when the fragments are moveable and pretty near each other; if they are separated laterally to a considerable extent, or if they are drawn far asunder by muscular contraction, or much blood lies between the broken ends, of course no crepitation can be felt, and in the case of bones much covered is often not easily produced. If,

therefore, we feel no crepitation, this does not prove, in opposition to the whole complexus of symptoms, that no fracture exists. But even if you feel crepitation you may still be deceived as to the origin thereof; a sensation of rubbing may also be produced on other occasions; under certain circumstances, for instance, the crushing of blood-clots and fibrinous exudations may cause a sensation of crepitation; but, with moderate practice in examination, you ought not to and will not confound this soft form of crepitation, which is analogous to the friction sound of pleurisy, with crepitation of bone; I will remind you, when occasion serves, of other forms of soft friction sound which occur, especially in the shoulder-joint in children and older subjects.

For an experienced surgeon violent pain confined to a particular spot in certain fractures may suffice for the formation of a correct diagnosis, especially as, in simple contusions, the pain, when the bone is taken hold of, is generally more diffused and seldom so violent as in the case of a fracture. On examining the extremities, it is best to clasp them with both hands at the point where we suppose that the fracture exists and to try to produce movement; this manipulation should be performed firmly, but, of course, without any rough force.

Concerning the *dislocation of the fragments*, there is something which I omitted to notice; it may differ extremely, but the dislocations may be classed in certain kinds which have from an early date been indicated by technical terms still in use, with which I must, therefore, now trouble you. Simple lateral displacement of the fragments is called *dislocatio ad latus;* if the fragments form an angle like a bent stick it is called *dislocatio ad axin;* if a fragment be twisted more or less about its axis, we say *dislocatio ad peripheriam;* if the broken extremities of bone be pushed together upwards, it is called *dislocatio ad longitudinem.* These terms are short and expressive, as well as easy to remember, especially if you make diagrams to represent the displacements.

We now pass on to the description of the *course* which the healing of the fracture pursues. You will seldom have an opportunity of seeing what happens when no dressing is applied, since injured persons, in the majority of cases, soon send for a surgeon. But laymen sometimes underestimate the importance of the injury; several days pass until, at last, pain and a continuance of the evil induce the patient to seek advice. In such cases you find, in addi-

tion to the above-mentioned symptoms of fracture, great œdema, but less frequently inflammatory redness in the neighbourhood of the point of fracture; the examination may, under such circumstances, be very difficult; the swelling is sometimes so considerable that it is impossible to form an exact diagnosis of the nature of the fracture. The earlier, therefore, we see a fracture the better. The external changes which occur at the point of fracture may be studied most easily in bones which lie superficially, and to which we cannot apply any dressing, *e. g.*, the clavicle. If the inflammatory œdematous swelling of the skin has decreased after seven to nine days and the extravasated blood run through its changes of colour and begun to be absorbed, there remains behind an immoveable tumour of firm consistency surrounding the point of fracture, which is larger or smaller according to the displacement of the fragments; it is, as it were, moulded around the fragments and becomes, in the course of the next eight days, of cartilaginous hardness; this is called the *callus*. Pressure upon it (the fragments being felt with difficulty through it) is still painful, although less so than before. Later on, the callus becomes quite firm, the broken ends of bone are no longer moveable, and the fracture may be regarded as healed. This requires about three weeks for a clavicle, for smaller bones a shorter, for larger bones a much longer time. The external changes do not end here, however; the callus does not remain as thick as it was at first; in the course of months and years it becomes thinner and thinner; and if no displacement of the fragments existed, nothing can eventually be observed about the bones. If there was a displacement which could not be rectified during the treatment, the ends of bone unite obliquely, and when the callus disappears the bone is left crooked.

To ascertain what deep-seated processes go on here, how the union of the broken ends of bone is effected, we have recourse to experiments upon animals; we cause artificial fractures in dogs or rabbits, then put on dressings, kill the animals at various intervals, and examine the fractures; we can thus obtain a complete view of the processes. These experiments have been made very frequently and always with results essentially similar, but if we confine ourselves first to what occurs in the rabbit, some differences present themselves which, as shown by a long series of experiments, depend upon the degree of displacement and the amount of extravasated blood. Before I show you, therefore, a series of such preparations, I must

tell you the general result of these investigations and explain them by means of illustrations, so that you may easily understand the slight modifications observable in the preparations.

We will occupy ourselves, first, with what can be seen with the naked eye or with a magnifying glass. If you examine three to four days after the fracture the bone of a rabbit and make a longitudinal section of it, you find the following state of things: the soft parts round about the point of fracture are swollen and firmly

FIG. 49.

FIG. 50.

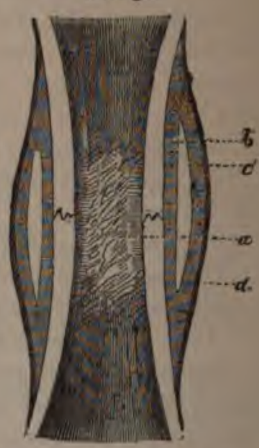


FIG. 49.—Fracture of rabbit bone of four days' standing without displacement. Longitudinal section: natural size. *a*, extravasated blood; *b*, swollen soft parts, external callus; *c*, periosteum.

FIG. 50.—Fracture of a cylindrical bone of fifteen days' standing. Longitudinal section. *a*, internal callus; *b*, internal, *c*, external bony layer of external callus; *d*, new periosteum. The dimensions of the callus are drawn much too large in proportion to the trifling displacement of the fragments, but this renders the illustration more intelligible.

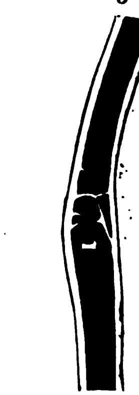
elastic; the muscles and subcutaneous cellular tissue have a lardaceous appearance; these swollen soft parts form a spindle-shaped, not very thick tumour round the point of fracture. Round about the fractured ends of bone we find some extravasated blood of a dark colour and the medullary canal of the bone is somewhat infiltrated with blood at the point of fracture; the quantity of this extravasated blood differs greatly, being sometimes very slight, sometimes rather considerable; the periosteum at the broken ends

of bone is recognisable and is more closely connected with the other swollen soft parts, in which there is plastic infiltration; sometimes it is slightly detached from the bone at the broken ends. The general appearance, therefore, is such as may be seen in Fig. 49.

If we now examine a fracture in the rabbit of ten to twelve days' standing, we find that the extravasated blood has either disappeared altogether, or that only a very small quantity remains, and I shall leave it an open question whether it becomes entirely reabsorbed or becomes partly organised as callus. The spindle-shaped swelling of the soft parts has, for the most part, the appearance and consistence of cartilage, and agrees therewith microscopically; in the medullary canal also we find fresh formation of cartilage in the vicinity of the fracture. The broken bone lies in this cartilage just as if the two fragments had been dipped into sealing-wax and stuck together; the periosteum is still tolerably recognisable in the cartilaginous mass, but it is swollen and has lost its outlines. Although young bone is now already formed in the callus, it can only be recognised by the aid of the microscope in this stage; with the naked eye we see only traces of the formation of bone; only some days later (from the twelfth to the twentieth day after the fracture) does it become quite distinct without artificial aid. We now recognise (see Fig. 50) in the vicinity of the broken ends of bone, young soft bone and that (1) in the medullary canal (*a*), (2) immediately upon the cortical layer (*b*), pretty far upwards and downwards, beneath the periosteum, which has become lost in the general, spindle-shaped callus-tumour, (3) in the periphery of the, for the most part, still cartilaginous callus (*c*). The periosteum, which formerly lay within the callus, has now disappeared and in its place a thickened layer of cellular tissue has been formed, externally upon the callus, which represents the new periosteum. The new bony mass is soft, white, and already presents a kind of structure, inasmuch as small portions of bone lying parallel to each other, corresponding to the transverse axis of the bone, are distinctly recognisable, especially when observed with a magnifying glass. The cartilaginous callus formed from the whole surrounding soft parts, in which also the periosteum is included, now forms an isolated whole and ossifies completely, partly from without (*c*), partly from within (*b*), until at last the ends of the bone are inclosed in the bony, as they were previously in the cartilaginous callus. This bony callus, which consists entirely of spongy bone-substances, is called after Dupuytren *pro-*

visional callus; on its completion the bone is, in the majority of cases, strong enough to fulfil its functions again. But just as little as the scarcely completely formed cicatrix of the soft parts is a stable tissue, equally little does the callus remain as it now is; a series of changes take place in it in the course of months and years, for so far you can still put forward the conception of union by means of sealing wax and that is, strictly speaking, no real organic incorporation. The rigid cortical substance is as yet united by a loose new bony mass, the medullary canal is closed by bone; the repair is not yet of a solid character; nature does much more than this. We will now study the changes which occur consecutively; they refer to the spongy substance of the callus. This ceases at a certain time to increase in size, and becomes changed in such a manner that the bony substance formed in the medullary canal is reabsorbed (Fig. 51) on the one hand, and that a great part of the external callus disappears on the other. Meanwhile, a new formation of bone has occurred between the broken ends of the cortical layer, so that the latter has become solid when the external and internal callus disappears. This connective bony substance between the fragments gradually becomes dense to such a degree that the hardness of normal bone is attained as it exists in the original cortical substance. In this manner, therefore, if no displacement of the fragments, or only a slight one existed, the bone becomes so completely restored that it is impossible, either during life or on examination of the preparation, to point out the situation of the fracture.

FIG. 51.



Fracture of a rabbit bone after twenty-four weeks. Longitudinal section. Advancing process of absorption of the callus. New formation of the medullary canal; natural size (according to Gurlt).

The changes just described are completed in a cylindrical bone of the rabbit, which has healed with the slightest possible amount of displacement, in about twenty-six to twenty-eight weeks, but occupy much more time in the cylindrical bones of man so far as we are able to judge from preparations which we now and then have an opportunity of examining.

The whole process so beautifully arranged by nature may essentially be traced back to processes which we also observe in the

normal development of the cylindrical bones, inasmuch as there, also, processes of absorption and thickening occur in the medullary canal and cortical layer perfectly similar to those with which we have just become acquainted in the callus. With the exception of the regeneration of the nerves, no such complete reproduction of an injured part of the human body occurs as that which has just come under our observation in connection with bones.

I must add a few remarks concerning the healing process in the flat and spongy bones. As regards the former, amongst which we have the most frequently occasion for observing the healing of fissures in the bones of the skull, the development of provisional callus is extremely slight, and even appears sometimes to be altogether wanting. In the scapula, where displacements of small fragments half or entirely driven out more readily occur, there is more frequently formation of external callus, although it never attains here any considerable thickness. The reunion of the spongy bones, in which, generally, no great displacement occurs, is also accompanied by but much slighter formation of external callus than in the cylindrical bones, while, on the other hand, the interspaces of the spongy substance in the immediate neighbourhood of the fracture become filled with bony substance, of which, indeed, a portion afterwards disappears.

Somewhat more complicated, of course, will be the conditions if the broken ends of bone are much displaced, or if single fragments are entirely broken off and at the same time displaced. In such cases there takes place so copious a development of callus, partly from the whole surface of the dislocated pieces of bone, partly also in the soft parts between them, that all the fragments are thereby enclosed to a certain length and organically united by the bony mass. The greater the extent of the tissues irritated by the dislocation of the fragments, the more extensive will be the formative reaction.

It is in the clavicle that we most frequently have an opportunity of observing in man the formation of callus resulting from great displacement of the fragments of bone, and it is easy to recognise therein that *the extent of the newly-formed bony substance increases in direct proportion to the amount of displacement.* You will easily understand how, in this manner, complete firmness may be attained, even with great deformity at the point of fracture, by a copious new-formation of bony substance. But we could scarcely believe,

without having been convinced by such preparations, that in the course of time, even in such cases, nature possesses the means, by processes of absorption and condensation, of restoring, not only the external form of the bone (with the exception of bending and twisting), but also the medullary canal. A great number of points, lumps, inequalities and roughnesses of various kinds, which are met with in the still recent callus, disappear in the course of months and years to such an extent that here also only a somewhat thickened, compact cortical substance remains (fig. 53).

FIG. 52.

FIG. 53.

FIG. 52.—Great displacement, with copious formation of external callus after fracture of tibia of a rabbit of twenty-seven days' standing; natural size (according to Gurlt).

FIG. 53.—Old, united, oblique fracture of human tibia; the broken ends rounded by absorption; the external callus reabsorbed; the formation of the medullary canal incomplete; reduced size (according to Gurlt).

It is of interest to trace out whence the newly-formed bony substance really comes by means of which such perfect results in respect to the union of bone are here attained. Is it the bone itself, is it the periosteum, or is it the surrounding soft parts which produce the newly-formed bony mass? or can it be that the extra-

vasated blood becomes converted into bone, as was asserted by the earlier observers? Must the formation of cartilage always precede that of bone, or is this not necessary? These are questions which have been answered very variously down to the present day. To the periosteum especially a considerable power of producing bone has sometimes been attributed, sometimes denied. I will now communicate to you briefly the results of my investigations in connection with this question.

The new-growth met with after the fracture is found infiltrated in the medulla and Haversian canals of the bone, in the periosteum, and in the adjacent muscles and tendons; I must leave it an open question whether the extravasated blood also contributes to the formation of the callus; a large amount of extravasation is detrimental here, as in the healing of the soft parts, since a small part

FIG. 54.

Longitudinal section of a piece of the cortical layer of a cylindrical bone in the vicinity of a fracture; *a*, surface; *b*, Haversian canals with blood-vessels and connective tissue; *c*, peritoneum. Diagrammatic drawing. Magnified 400 times.

only becomes organised while the remainder must be removed by absorption. The inflammatory new-growth itself consists at first here also of small, roundish cells, which increase greatly in number and infiltrate the tissues mentioned above, finally taking their place almost entirely. Before we follow up further the destiny of this cell-formation I must allude briefly to *the manner in which this process is carried out in the Haversian canals;* the cell-infiltration in the connective tissue of the medulla presents nothing particular except that the flat-cells of the medulla disappear in proportion as the new cells occupy the ground. Represent to yourselves in the following illustration (fig. 54) the surface of the bone in the

neighbourhood of a fracture; the Haversian canals open, as you are aware, on the surface of the bone, and contain blood-vessels surrounded by a little connective tissue.

Cells appear first in great number between the bundles of connective tissue in the Haversian canals; if this cell-infiltration occurred very rapidly, the blood-vessels would thereby become thoroughly compressed and the bone would die at that point, a process with which we shall become acquainted later on. But if the growth of the cells in the Haversian canals takes place slowly, a gradual absorption of the walls of these cells occurs, caused, apparently, by the inflammatory new-growth itself; the canals become wider and filled with cells and the blood-vessels increase in number at the same time by anastomosis. Langer asserts that he has frequently seen two in the same canal.

From the observations of Cohnheim we may assume that also in inflammation of bone, the young cells in the Haversian canals are not all newly formed, but consist, in a great measure, of white blood-corpuscles issuing from the blood-vessels.

Let us now turn our attention to the changes in form which are observable in the bony tissue. Since the connective tissue of the bony canals is in continuous connection with the periosteum, as well as with the medulla, so is also the cell-infiltration which occurs in the bone, periosteum, and medulla at once continuous. The cause of the decrement of bone in the walls of the Haversian canals, which occurs in this as in many other new formations of bone, is very difficult to explain; that the connective tissue and the muscular substance, as well as other soft tissues, waste if the inflammatory new-growth becomes established in them is less surprising; but that the hard bony mass should be softened and removed by it is certainly very striking. The representation of what occurs in this process is given in the following illustration (Fig. 55).

You see that the dilatation of the bony canals is not regular but indented; the bone appears as if it had been gnawed out; this is not necessarily always so, but the decrement of the bone may also be more gradual. These recesses are formed here, in my opinion, by the accumulation of cells in groups, for the most part giant cells, as we meet with them also in the medulla of normal young bones, and which, according to Wegner's observations, frequently grow out from the walls of the vessels or through the loops of the vessels themselves, which press against the bony tissue and thus cause its

absorption. Virchow and others believe that these recesses correspond to the nutrition districts of individual bone-cells, which are assumed to contribute in this process to the absorption of the bone. I think that I have refuted this view by demonstrating that pieces of dead bone also and ivory are similarly attacked by the inflammatory new-growth, of which more in connection with pseudarthrosis.

It is not known as yet how the solution of the salts of lime in the bone is effected in this absorption; I look upon it as probable that the new-growth in the bone develops lactic acid, and that the carbonate and phosphate of lime are thereby converted into soluble lactate of lime, which becomes absorbed and carried off by the vessels; *but this is a mere hypothesis.* It is also possible that the

FIG. 55.

Inflammatory new-growth in the Haversian canals. *a*, surface; *b*, Haversian canals, dilated and filled with cells and new vessels; *c*, periosteum. Diagrammatic drawing. Magnified 400 times.

organic framework of the bone, the so-called bone-cartilage, becomes dissolved by the inflammatory new-growth, whereby a slight crumbling of the chalk-substance would necessarily be produced, the molecules of which might eventually be carried away even undissolved. But of all the chemists and physiologists with whom I have spoken on this subject not one has hitherto been able to give me a simple explanation of this process, or to suggest a mode of experimenting by means of which we might solve with certainty the question at issue.

Represent to yourselves in the illustrations given above the surface of the fracture upon which, of course, there is no perios-

teum, instead of that of the bone, and you will understand how, from this surface, the new-growth (the fresh callus) advances from the Haversian canals in the manner described, comes in contact with the similar new-growth of the other fragments and unites with it, as in the healing process in the soft parts. It is self-evident that the portion of bone thus penetrated by the inflammatory new-growth, in consequence of the absorption which is effected in the walls of the canals, must become porous; if you macerate a bone at this stage, so that the whole new-growth decomposes out, you ought to find the dry bone, where new bony growth has been formed either externally or in the medullary canal, porous, although generally to a very slight depth only.

I must again point out that, for the sake of distinctness, we have here, in our illustrations and descriptions, assumed the extent of the callus-formation to be much greater than it generally is in reality, and that here also, as well as in injuries to the soft parts, the regenerative processes after simple wounds do not usually extend very far or very deep under normal circumstances, but perform only what is requisite for the healing process, very seldom indeed furnishing an excess.

In the whole of this description we have made no mention of the bone-cells or star-shaped bony corpuscles; I am convinced that they play no greater part in these processes than the solid cells of the connective tissue in an inflammatory nest, but rather become dissolved with the bony tissue, as in other soft tissues, if the inflammatory process reaches a certain height, and take no part in the inflammatory new-growth in the bone. There are, however, differences of opinion on this point, as many investigators have assumed that the bony cells in the star-shaped openings of bone become themselves divided and form the callus-tissue, while the bony tissue in the vicinity of the bone-corpuscles must, of course, disappear. I admit this unconditionally for the softer periosteal layers of bone in growing animals, but it does not appear to me proved that it occurs in the fully formed cortical tissue of full-grown cylindrical bones such as we are now speaking of.

We know this new-growth as yet only in the state in which it consists essentially of cells and vessels, as under similar circumstances in the soft parts; if now, as there, retrograde formation as a cicatrix of connective tissue occurred, we should have no solid union of bone but a union by means of connective tissue, a *pseudarthrosis*,

or false joint. Of such an exceptional joint we will speak further on. Under normal circumstances the new-growth now becomes completely ossified, as you are already aware. This ossification may either occur directly or after the new-growth has previously been converted into cartilage. You know that in the normal growth of the bones both of these things occur, direct ossification of new cells, as they lie, for instance, in the periosteum of the growing bone, or formation of cartilage with consequent ossification, as in the entirely cartilaginous præformed skeleton and in cases of tardy growth of the bones.

Fig. 56.

Ossifying, inflammatory new growth on the surface of the bone and in the Haversian canals. Osteoplastic periostitis and ostitis. Diagrammatic drawing. Magnified 400 times.

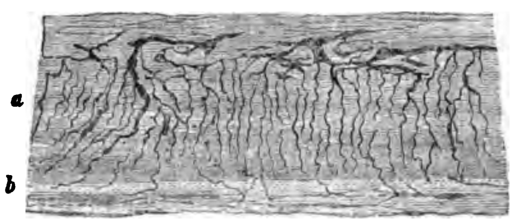
The callus, in cases of fracture, differs remarkably in this respect in man and animals. The new callus in the rabbit is usually at once converted into cartilage before it ossifies and also in children. In full-grown dogs the callus usually ossifies directly, just as in full-grown men; we are far from knowing the causal moments of these differences.

If, for the purpose of forming for ourselves a preliminary histological idea of these processes, we return to our earlier illustration (Fig. 55), you must represent to yourselves that the cells which lie

in the gaps formed in the Haversian canals and the surface of the bone by absorption very soon become ossified after they have filled these gaps (Fig. 56), but then accumulate on the surface and in the medullary canal; they thus form the external and internal callus. Periostitis and ostitis tending chiefly or exclusively to the formation of new bone are called *osteo-plastic;* the callus is the result of a traumatico-osteoplastic ostitis.

The periosteum, as already remarked, becomes lost in the new growth and in the ossifying callus, while the outer layer of the callus becomes converted into a close connective tissue and forms the new periosteum of the bone at the point of fracture and in its immediate vicinity (as far as the callus extends). In illustration of the processes in the periosteum I will show you some further preparations. You see (Fig. 57) the peculiarly extended course

FIG. 57.



Artificially injected external callus of slight thickness on the surface of the tibia of a rabbit, in the vicinity of a fracture of five days' standing. Longitudinal section. *a*, callus; *b*, bone. Magnified 20 times.

almost at right angles to the bone, of the larger branches of the vessels which enter through the new external callus into the bone. The ossification of the callus commences first as a mantle around these vessels, and thus arise the small pillars of bone which appear at first in the external callus (compare remarks at Fig. 50).

You may obtain a good idea of the formation of the external (periosteal) and internal (endostal) callus by means of the following (not, indeed, quite perfect) transverse section of the tibia of a dog from the immediate vicinity of a fracture of eight days' standing, in which you must observe the vessels of the cortical substance, which are considerably larger than the normal size (Fig. 58). Lastly, examine also the following preparation: it is an already ossified

external callus on the surface of a cylindrical bone in the vicinity of a fracture (Fig. 59).

If we now sum up once more the whole process, we find that *the cell-infiltration in the bone itself, as well as in all the surrounding parts, contributes to the formation of the callus, and that the periosteum, therefore, plays no exclusive osteo-plastic part therein.* We might, indeed, already have inferred this *à priori* from the fact that, if the periosteum alone formed the external callus, as was formerly

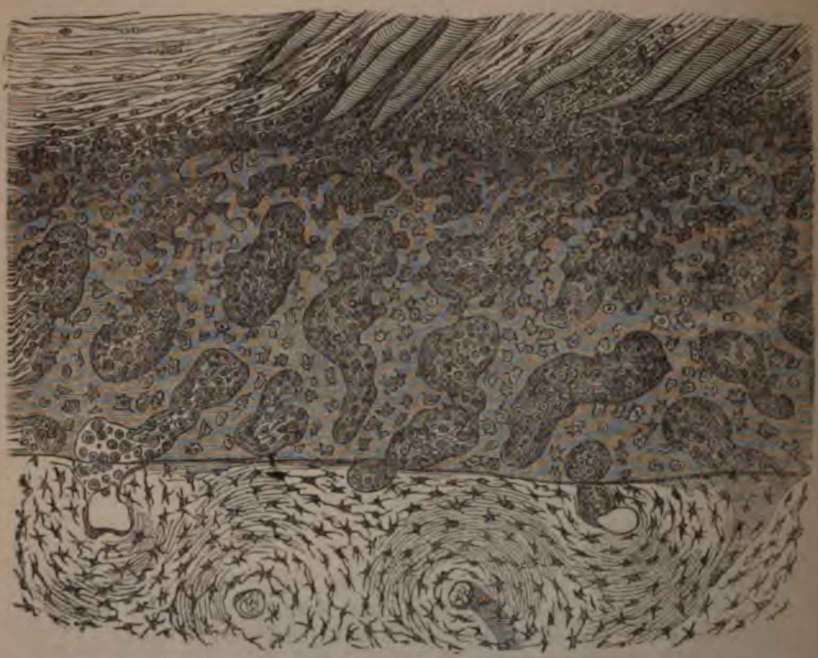
FIG. 58.

Artificially injected transverse section of the tibia of a dog from the immediate vicinity of a fracture of eight days' standing. *a*, internal callus; *b*, external callus; *c*, *c*, cortical layer of the bone. Magnified 20 times.

assumed, the parts of the bone deprived of callus, *e.g.* points at which tendons are attached to the bone, could not form callus, which is in direct opposition to our experience. In normal growth also the periosteum by no means plays the exclusively osteo-plastic part which many writers attribute to it, inasmuch as we may regard the layer of new cells which adjoins the surface of the bone, and extends into the Haversian canals, as belonging no less to the bone than to the periosteum. More recent investigations of the growth of bone by J. Wolff render it, indeed, very probable that the bones also increase by the interstitial deposit of new bony tissue in all

directions, and thus the apposition-growth of the bones by means of the cartilages of the epiphyses and the periosteum would no longer be the only source of their increase in length and thickness. That the latter mode of growth of bone undoubtedly exists is especially proved by an excellent work by Wegner on the osteo-plastic effect of phosphorus on growing bones, and by a very recent experimental work of the same author, which, equally with a work by Maas,

Fig. 59.



Ossifying callus on the surface of a cylindrical bone in the immediate vicinity of a fracture. Longitudinal section. Magnified 300 times. We see that the ossifying callus is not confined to the periosteum, but extends inwards between the muscles.

reinstates the views of Flourens concerning the growth of bone entirely in their former rightful position.

I will not conceal from you that the opinion propounded and so obstinately defended by me, that the bone-cells in new growths within the bone are not prolific but behave quite passively, has been attacked on many sides. After Cohnheim had demonstrated the

passivity of the stable corpuscles of connective tissue in the inflammation-nest during the acute suppurative period, my opinion given many years ago, and based upon numerous observations, can no longer appear strange; but the interpretation of the respective preparations is by no means so simple as to leave room for one conclusion only. Lossen has recently, by means of very careful investigations into the histological processes during the conversion of the provisional into the definitive bony callus, attempted to show that the bone-cells of the former take an active part in the formation of canals for the vessels in the latter by dilatation and changes of position. I can admit this as being perfectly correct without abandoning my former view, for the provisional callus is, like the new osteophyte, calcified connective tissue, as certain boundary layers between cartilage and bone are calcified cartilage. That the cells of this "osteoid cartilage" (Virchow), like the cells of hyaline cartilage, especially before the definitive conversion into true bone, are prolific, I do not doubt. This is not the place to go more deeply into the histological details, which, however interesting they may be in themselves, are still without essential influence upon the definitive forms of new growths in bone.

LECTURE XV.

Treatment of simple fractures.— Reduction.— Time of applying the dressing.—Choice thereof.—Sulphate-of-lime dressings, starch dressings, dressings with splints, permanent extension; position-apparatuses.—Indications for removing the dressing.

WE will now pass on at once to the treatment of simple or subcutaneous fractures, especially in reference to fractures of the extremities, for these are by far the most frequent and also require especially a treatment with dressings, while fractures about the trunk and head have to be treated less by dressings than by appropriate position, as is taught in the lectures on special surgery in the surgical clinique.

The problem now before us is simply this, to set right any existing displacements and to fix the fractured extremity so long in the right position anatomically as is necessary for the healing of the fracture.

The first thing to be done is *to replace the fragments;* this may, in certain cases, be quite unnecessary, for instance, when there is no displacement, as in many fractures of the ulna, fibula, &c. In other cases it is very difficult and not always completely feasible. The resistances which oppose themselves to the replacement may be situated in the position of the fragments themselves; one fragment, for instance, may be firmly wedged into another, or a small fragment is placed so obstructively between the two chief ones that the latter cannot be brought into exact apposition. Very obstinate in this respect are fractures of the lower end of the humerus, in which small fragments may become so displaced that neither flexion nor extension of the elbow-joint can be fully carried out and the function of the joint thus remains permanently impaired. A second obstacle to the replacement occurs from the contraction of the muscles; the patient involuntarily contracts the muscles of the

fractured extremity, rubs thereby the fragments against each other, or presses them into the soft parts and thus causes himself the most violent pain; these muscular contractions are sometimes almost tetanic, so that it is scarcely possible, even with great force, to overcome the resistance. These difficulties were, in fact, formerly almost entirely insurmountable and if it was sometimes attempted, by the division of tendons and muscles, to attain that object, it was still necessary to be content with an imperfect replacement. All these difficulties were removed at once by the introduction of chloroform as an anæsthetic. In all the cases in which we do not succeed in replacing the fragments we narcotise the patient with chloroform until the muscles relax completely, and then generally succeed in replacing them without difficulty. Many surgeons go so far as to administer chloroform in almost every case of fracture, partly for examination, partly for the application of the dressing. This is unnecessary; the use of chloroform may have very unpleasant consequences if we have to do with people, especially drinkers, who are seized at a certain stage of the narcosis with convulsive twitchings of the extremities, so that, in spite of the efforts of powerful assistants to prevent it, the broken fragments are rubbed against each other with a loud grating sound and there is great cause for fearing that a pointed fragment may perforate the skin. You must not let this deter you from administering chloroform when necessary, but it should warn you to be sparing of its employment. The manner in which the replacement is effected is generally this: the broken part of the extremity is grasped by two powerful assistants at the joints above and below the fracture and steady traction made, while the operator takes hold of the extremity at the point of fracture and seeks to push the fragments into position by gentle pressure. All sudden jerking or forcible dragging is unnecessary and decidedly to be avoided. There are two technical expressions to be borne in mind here; the pull applied to the lower part of the extremity is called *extension*, the fixing of the upper part *counter-extension*. Both acts are to be performed with the hands in cases of fracture, while in dislocations other mechanical aids are sometimes necessary. An exact replacement in the above manner will be impossible if, partly on account of too much swelling, partly of an especially unfavorable displacement of the fragments, we are unable to recognise the exact nature of the latter.

According to our present principles, which are based upon a long

series of experiences, the more immediately after a fracture the replacement is made the better; the dressing is then to be applied at once. Surgeons have not always taken this view, but waited formerly as well with the placing of the fracture in position as with the application of the dressing, until the swelling, which almost always sets in if the dressing is not applied immediately, had subsided. It was feared that the pressure of the bandage might cause the wound to become gangrenous and prevent the formation of the callus. The former is easily to be avoided by certain precautions in applying the dressing; in the latter there is some truth. As regards the choice of the dressing to be used, surgeons have very recently become almost unanimous in their views on this point. *It is to be regarded as the rule that in all cases of simple subcutaneous fractures of the extremities, a firm, compact dressing should be applied as soon as possible,* which may be changed two to three times, but in very many cases does not require to be changed at all. This kind of dressing is called the *immoveable* or *compact dressing,* in opposition to the moveable dressings which must be renewed every few days and are now only regarded as provisional dressings.

There are several kinds of compact dressings, of which the *plaster-of-Paris,* the *starch,* and the *silicate-of-potash* dressing are those most in use. I will show you first the plaster-of-Paris dressing and the mode of applying it, for it is the one most frequently used, and meets all the requirements in such a manner that any improvement appears almost impossible.

Plaster-of-Paris dressing.—When, after successful replacement of the fragments, the fractured extremity has been fixed by two assistants by means of extension and counter-extension, we take one or even more layers of wadding and place them partly around the point of fracture, partly upon spots at which the skin lies close upon the bone, *e.g.* upon the crista tibiæ, the condyles, and malleoli of the leg. We now take by preference a rolled bandage of new fine flannel, and bandage the limb therewith, so that an equable pressure is made everywhere, and all the parts are covered which we wish to surround with the plaster-of-Paris dressing. In hospitals and in practice amongst the poor, where good flannel bandages are not always procurable, soft cotton or gauze bandages may be used. Now comes the putting on of the plaster-of-Paris bandage prepared for this purpose; this bandage which I have here is cut from a very thin material resembling gauze; it is prepared in

such a manner that finely powdered plaster of Paris (so-called modeller's plaster of Paris) is strewed uniformly upon the bandage, which is then rolled up. For private practice we may have a number of larger and smaller bandages of this kind prepared and keep them in a closely fitting tin case. Here in the hospital, where a large number of these plaster-of-Paris bandages is used, a stock is prepared twice or three times a week. You place such a bandage in a vessel full of cold water, allow it to become thoroughly moistened, take it out of the water and roll it like any other bandage around the limb prepared in the manner mentioned above. A three-, at most fourfold layer of this plaster-of-Paris bandage suffices to produce a compactness in the dressing such as is required for our purpose. In about ten minutes good plaster of Paris sets so firmly that we may loosen our hold of the limb and put it upon the bed; in half an hour or an hour the dressing generally becomes as hard as a stone and dry; this interval depends partly upon the goodness of the plaster of Paris and partly upon the extent to which the bandage had become moistened. If the plaster of Paris is bad, if it is damp, large-grained, and dirty, it will not set well; if we wish to expedite the setting of the plaster of Paris we should throw half a handful of alum into the water in which we intend to moisten the bandage. Plaster of Paris which has become damp may be rendered more available by drying it highly in an oven, but it never returns entirely to its former condition.

The mode of applying the plaster-of-Paris dressing just described is the one which I have found most efficacious after comparing it many times with other methods. I must, however, mention to you some modifications in reference especially to the manipulation of the plaster of Paris and of the material for the bandages. We may, namely, also rub the plaster of Paris into the ordinary cotton or even flannel bandages, whereby the dressing becomes somewhat heavier and closer, but this is not necessary, and the loose gauze material is very much cheaper than the woven cotton bandages. If the dressing does not appear sufficiently firm, a layer of moistened plaster of Paris may be put over the whole of it. The plaster of Paris must be carefully stirred up with water and very quickly laid with the hand or a spoon over the whole dressing and rubbed in. The plaster of Paris must not be moistened until the last moment, as it sets very quickly. This dressing, carried out by means of bandages, was first suggested and employed by a Dutch surgeon,

Mathysen, and was made known as early as 1832, but has only become more generally known since about 1850. In Germany it has been made familiar chiefly by the Berlin school.

Somewhat different is the mode of procedure when the plaster-of-Paris dressing is applied in single detached pieces. Pirogoff first introduced this modification when in want of dressing-material in the field. Any pieces of stuff which could be cut into the form of sufficiently long splints were drawn through a thin mixture of plaster of Paris and water and laid about the broken limb, the whole then covered with plaster of Paris as usual, and a very firm case was thus made. Later on the same surgeon formed this into a special method by cutting coarse sail-cloth according to certain rules for each extremity and applying it in the manner just mentioned. Lastly, the so-called many-tailed bandages of Scultet have been used in a similar manner for plaster-of-Paris dressings. Further, the inner layer of the dressing is modified in various ways; sometimes neither wadding nor inner bandages have been used, but the whole limb smeared freely with oil, so that the plaster of Paris applied directly to the skin may not stick to it and the fine hairs. Others have only used very thick layers of wadding without any special inner bandages. Lastly, thin wood-shavings or thin strips of tin have been placed next the skin. This may have some advantages for perforated dressings, as we shall see later on.

I have presented to you all these modifications of the plaster-of-Paris dressing intentionally as exceptional modes of proceeding only, all of which have certain disadvantages compared to the method given first as the regular one. A closer criticism of these modifications I shall reserve for the clinique.

The removal of the plaster-of-Paris dressing presents great difficulties to the unpractised, and yet you will see that every one of my female nurses can do this in the shortest possible time and most gentle manner. This is done simply as follows: with a concave, strong, sharp garden knife we cut through the plaster-of-Paris bandages, and that not quite perpendicularly, but *much* more easily in a somewhat oblique direction, down to the inner bandage, and then take the whole dressing to pieces like a hollow capsule; or we may use the plaster-of-Paris scissors recommended by Szymanowski, or those of v. Bruns, Leiter and others. The capsule thus removed may sometimes be used again for provisional dressings.

Starch dressing.—Before plaster of Paris was known, we already

possessed in the starch dressing a very excellent material for immoveable dressings. The starch dressing was chiefly brought to the highest degree of its perfection and introduced into surgical practice by Seutin; it is only about twenty years since it was supplanted by the plaster-of-Paris bandage, but it is still employed occasionally. The laying on of the wadding and inner bandage is the same as with the plaster-of-Paris dressing; but after that, splints of moderately thick pasteboard, previously cut into proper shape and thoroughly softened in water, are placed around the limb and kept in position by bandages which have been well soaked in starch. Until this dressing becomes hard, which, at the ordinary temperature of a room, requires somewhat more than twenty-four hours, wooden splints must be applied which are afterwards taken off. This dressing has the disadvantage, as compared with the plaster-of-Paris dressing, that it sets very much more slowly. This may be obviated to a certain extent by taking *pieces of gutta percha* instead of the pasteboard splints, soaking them in hot water, and then adapting them exactly to the limb. Gutta-percha straps, as they are used in manufactories, are very available for splints. It cannot be denied that the introduction of gutta percha for surgical dressings is to be regarded as a great advantage, but the price of the material is too high to allow of its employment in hospital practice for every case of simple fracture, while it is also somewhat inconvenient that hot water is always required for the softening of the gutta percha. Thick gutta-percha splints become hard almost more quickly than plaster of Paris. The dressing with bandages soaked in plaster of Paris is so superior on account of the facility with which it is put on, as well as on account of its cheapness and compactness, that, having now been introduced into practice, it will certainly never be supplanted by the starch dressing.

In the place of the starch, solutions of dextrine, white of egg, and even meal and water mixed together, have been used formerly. These are all obsolete, but it is well that you should be aware of the value of such substances, since they are to be found in every household, and may, therefore, very well be utilised for provisional dressings.

Silicate-of-potash dressing.—Instead of the starch, we may employ with advantage the solution of silicate of potash of commerce. It is to be spread with a large brush upon the cotton bandages when the dressing is applied, after the limb has been covered with wadding

as already described. The silicate of potash dries more quickly than the starch, but not so quickly as plaster of Paris, neither does it become so firm as the latter. This dressing suffices for fractures in which there is no tendency to displacement. If we would fix in position with the silicate of potash dressing displaced ends of broken bone, we must strengthen it by means of splints.

I have no doubt that before long every country practitioner will have some plaster-of-Paris bandages in stock, but *provisional dressings* have, nevertheless, their practical value. These consist of bandages, compresses, and splints of very various kinds of material; the splints may consist of thin wooden board, cigar boxes, pasteboard, tin, leather, straw twisted tightly, bark of trees, &c.; and in the cottages of the poor you will often have to be content with old rags and linen, cut into strips and sewn together, as bandages; it is therefore necessary that in the practical lessons on bandaging you should make yourselves familiar with the use of the most varied materials.

It is not my object here to present to you everything that may be made available for dressings, but there are some points to which I must briefly allude. Dressings with splints have for their object, evidently, to place the bone in a firm and immoveable position by means of strong supports on one or more sides; we can attain this with narrow wooden splints applied on all sides of the limb, or we may employ concave splints. The latter are useful only when composed of a pliable material, such as leather, thin tin plates, wire gauze, &c.; a perfectly stiff concave splint would suit a few individuals only.

In contrast, as it were, to the mechanical means just mentioned, there is another method of fixing broken limbs, namely, by *permanent extension*. This idea lay very near at hand for those cases especially in which there was a great tendency to the *dislocatio ad longitudinem*, or shortening. It has been sought to produce this extension partly by weights applied with a mechanical arrangement of various kinds, partly by a permanent pull produced by weights attached to the injured limb, and partly by the double inclined plane, where the weight of the leg is used as the extending weight. Having seen, in the course of the last two years, very unexpectedly important results from permanent extension with weights in very painful contractions about the hip- and knee-joints, I have also employed this method for the gradual adaptation of broken ends of

bone and found it very useful. Amongst the contrivances of this kind known to me, the so-called railway apparatus introduced by v. Dumreicher fulfils the purpose of permanent extension best of all, but it is too expensive and too complicated to come into use to any great extent in private practice. It is, no doubt, the intention of the inventor to use this apparatus chiefly for cases in which there is displacement difficult to overcome. The double inclined plane, represented by a thick round cushion placed under the knee, may sometimes be used for the *fractura colli femoris* in very old people, as a practical means of fixation if we do not wish to apply any dressing. The extension-dressing with adhesive plaster, as first introduced by American surgeons and made largely known in Germany by Volkmann, has proved to be the most practical; it often does excellent service, especially in cases of fracture of the thigh.

There are still some auxiliary means to be mentioned which we must employ *for placing the broken limb in a favorable position* after the dressing has been applied. For the upper extremity, a simple, properly applied cloth, in which the arm is laid, suffices in most cases. We may allow patients with a plaster-of-Paris dressing, and such an arm-cloth, to remain out of bed with a broken upper or fore-arm during the whole treatment without at all interfering with the healing process.

For the placing in position of broken lower extremities a long series of mechanical auxiliary means exists, of which the following are the most usual: *sand bags, i. e.,* narrow bags filled with sand, of about the length of the leg, to be laid on both sides of the compact dressing, so that the limb cannot be moved about. For many cases a bag loosely filled with chopped straw or chaff suffices. A depression is made in its upper surface longitudinally into which the leg is placed. If a firmer support is required, we use for *leg splints* thin long wooden boxes without lids into which the leg is placed and of which the other side pieces can be put down, so that the limb can be inspected without raising it. This apparatus can be raised or lowered as is most comfortable to the patient. Swings must also be mentioned, which keep the limb in an oscillating position and possess certain advantages in the case of restless patients. You must render yourselves familiar with all these apparatuses, which, although less employed now than formerly, are occasionally of use, opportunity for which you will have in the surgical clinique.

All these apparatuses for the placing of fractured lower extremities in position have been less employed recently; my former assistant, Dr. Ris, who has brought the application of the plaster-of-Paris dressing to a high pitch of perfection and elegance, places on the under side of the leg a well-padded wooden splint with plaster-of-Paris bandages, about three to four inches broad, which reaches somewhat beyond the heel and as far as the knee, or in cases of fracture of the thigh, as far as its middle. On this board the limb lies very firmly if the mattrass is not a bad one. If we wish for still more firmness, we place in the lower third of the bed a board as broad as the bed upon the mattrass, and upon this the extremity with its plaster-of-Paris dressing and position-splints. For the many double fractures of both extremities which were brought into the Zurich hospital, this position-apparatus rendered especially good services.

The older form of the plaster-of-Paris cast has recently been recommended anew by M. Müller. We have lately again occupied ourselves with it, but it cannot bear comparison with the plaster-of-Paris dressing; it is much more complicated in its application and in the attention required with it.

Seutin attempted to increase the advantages of the compact dressings by proposing auxiliary means by the aid of which patients with fractured lower extremities might be enabled to move about to a limited extent. Thus a patient with a broken leg may, by the aid of a broad leather strap passing over the shoulder and buckled on close above the knee, so that the foot does not touch the ground, go about on crutches. I would advise you, however, not to push these experiments too far with your patients; at all events I do not permit my patients to make such attempts at locomotion before the end of the third week after the occurrence of the fracture, because œdema is readily caused in the broken extremity, and many patients are so awkward in the use of the crutches that they are very liable to fall and may cause concussion of the injured part, which, although slight perhaps, may prove detrimental to it.

Lastly, we have to discuss how long the dressing is to be left on and what the circumstances are which may induce us to remove it before the definitive cure. To judge whether a dressing has been put on too tight is a matter of experience; the consequences must guide us here. If the lower part of the limb, *i. e.*, the fingers or toes, which are generally left free, swell and become of a blueish-

red colour, cold, or even deprived of sensibility, the dressing must be taken off *at once*. If the patient complain of violent pain under the dressing, it is better to remove it, even if nothing objective present itself on doing so. As regards complaints of pain, we should know our patients; there are some who are always complaining, while others are very indolent and speak little about their sensations. In any case it is better to renew a dressing several times unnecessarily than to neglect to do so once at the right moment. I cannot urge upon you too strongly to make it an absolute rule in practice never, after having put on a compact dressing, to let more than twenty-four hours pass without seeing the patient, to make any change that may be necessary. No harm will then befall your patients, as unfortunately has but too often occurred from carelessness and indolence on the part of the surgeon in charge. There are a number of cases on record in which, after the application of compact dressings, the injured extremity became gangrenous, and amputation necessary; strange to say, it was concluded from these cases that compact bandages generally were unpractical, while the fault lay with the surgeon. Consider how slight the trouble in the treatment of fractures now is as compared with former times, when a dressing with splints had to be renewed every three or four days! Now we not unfrequently have to put on a single dressing only. Do not imagine, however, that you are no longer required to practise yourselves in the application of bandages. *The application of compact dressings requires just as much practice, address, and circumspection as formerly the application of splint dressings.* If you are sent for to a case of fracture on the second or third day only, and a considerable amount of inflammatory swelling already exists, you may still apply a compact dressing, but must use wadding freely and not put on the dressing too closely. Such a dressing must naturally become too loose after ten or twelve days, when the swelling of the soft parts has subsided, and must then be removed and renewed. It will depend essentially upon the loosening of the dressing and upon the greater or less tendency to displacement, when and how often the dressing must be taken off before the cure is completed. Great swelling, if not connected with much contusion, is not a contraindication for the employment of a carefully applied compact dressing; nor are larger or smaller blisters filled with clear or slightly bloody serum a serious obstacle; such blisters not unfrequently appear with contused fractures when

there is extensive laceration of the deep veins, since the obstruction to the return of the venous blood readily causes the serum to pass out of the capillary vessels and push up the horny layer of the epidermis; such blisters must be pricked, the fluid pressed out gently and wadding applied, which soon dries on. The same holds good for slight superficial excoriations of the skin; it is but seldom necessary, if fresh blisters occur under the dressing, which is made known by pain, to remove and renew the dressing on that account.

How long, in general, a compact dressing must remain on for fractures of the individual bones you will learn partly in the clinique and partly in special surgery; I will mention here as extreme periods that a finger requires about fourteen days, a thigh sixty days or more, for its complete cure. If you apply plaster-of-Paris dressings immediately after the fracture, with complete replacement of the fragments, the external provisional callus will always be very small, and, consequently, firm union occur later than with displacement and later application of the dressing; this has not, however, any influence upon the formation of the definitive callus, the actual union of the broken ends of fractured bone with each other.

CHAPTER VI.

ON OPEN FRACTURES AND ON SUPPURATION OF BONE.

Difference between subcutaneous and open fractures in reference to prognosis.—Varied character of the cases.—Indications for primary amputation.—Secondary amputation.—Course of the healing process.—Suppuration of bone.—Necrosis of the ends of fragments.

We will now pass on to compound or open fractures.

If we speak simply of *compound fractures* we generally mean thereby such as are combined with wounds of the skin. This is, strictly speaking, not quite exact, because there are various other complications some of which are of much greater importance than a wound in the skin. If the skull is fractured and at the same time a portion of the brain substance crushed, or if ribs are broken

and a part of the substance of the lung torn, these are also compound fractures even if the skin coverings remain uninjured. But because in such a case the complication in itself is of much greater importance for the general organism than the fractured bone, such cases are usually described as compression of the brain or laceration of the lung resulting from fracture of the skull or ribs. But we will not enter here into the question of injuries to internal organs by fragments of bone, because a very complicated state of disease is not unfrequently produced thereby, the analysis of which you will not be able to understand until later. Let us confine ourselves at present to fractures of the extremities combined with wounds of the skin, which we will designate as *open fractures*, and which will cause us anxiety enough in reference to their course and treatment.

I have already pointed out to you, when speaking of simple contusions without wounds and of true *contused wounds*, how easily in so many cases the absorption of the extravasated blood and the healing of the contused parts take place where the whole process is carried on subcutaneously, but how greatly the conditions are changed when the skin also is injured. The chief dangers in such cases are, as you will remember, processes of decomposition about the wound, extensive necrosis of contused and dead tissues, tedious, exhausting febrile conditions accompanying progressive suppurations. In addition to these, but not yet mentioned, we meet with the most severe general diseased conditions, such as traumatic erysipelas, putrid blood-poisoning, pyæmia, traumatic tetanus, delirium tremens. The contrasts between subcutaneous injuries and open wounds, in reference to the course and prognosis in simple subcutaneous fractures as compared with open fractures, are much more sharply marked than in simple contusions as compared with contused wounds. While we should scarcely call a man ill in many cases who has a simple fracture (we have said nothing of fever in such cases because it seldom occurs), and such an injury, with the present convenient method of treatment, is to be regarded rather as an inconvenience than a calamity; every open fracture of one of the larger bones of the extremities, and even, under certain circumstances, of a finger bone, may produce serious and, unfortunately but too often, fatal diseases. It gives me, therefore, great satisfaction to be able to add that the improvements in surgical treatment in this department especially have been very great in the course of the last decenniad.

One of the most difficult and important of our problems is, to form from the first a thoroughly correct prognosis of an open fracture. The life and death of an individual may here sometimes depend upon the choice of the treatment during the first few days, and we must, therefore, now already enter somewhat more deeply into this question. The symptoms of an open fracture are, of course, essentially the same as those of a subcutaneous fracture, except that the coloration by extravasated blood is often wanting, because the blood passes out of the wound, in part, at least. The broken ends of bone not unfrequently project from the wound, or lie in full view in it, so that a glance suffices for the diagnosis of an open fracture. But this is far from being enough, for we must try to ascertain as exactly as possible how the fracture was caused, whether by direct or indirect violence, how great the force has probably been, whether dragging and twisting were combined with the contusion, whether arteries and nerves have been torn, whether the patient lost much blood, and what his present general condition is. There are cases in which we can say at the first glance that no cure is possible, and that amputation is absolutely necessary. If a locomotive passes over the knee of an unfortunate railway labourer, if a hand or forearm gets in between the wheels or rollers of a machine in motion, if, from too early explosion of a blasting charge, limbs are smashed and lacerated, or immense weights completely crush a foot or leg, it is not difficult for the surgeon to make up his mind at once to a *primary amputation*, and the condition of such extremities is generally such that the patients also soon consent, though with a heavy heart, to the operation. These are not the difficult cases. Just as easy may it be, under certain circumstances in other cases, to predict the probability of a good recovery with tolerable certainty. If, for instance, the fracture of a leg results from indirect violence, or from excessive bending of the bone, the broken pointed end of the *crista tibiæ* may pierce the skin and project; in such a case there is no contusion, but only a simple slit in the skin. Again, if a semi-sharp body strikes a small point of the extremity with great force, and bone and skin are injured, the whole extremity may be much shaken while the field of the injury is but small, and in the majority of such cases a favorable result may be expected with appropriate treatment.

The cases difficult to judge of lie in the middle between these two extremes. In cases in which a certain amount of contusion has

occurred, but of which little is visible, while the skin is injured at a small point only, it will be very difficult to decide whether we shall attempt the cure or proceed at once to amputate, and only the peculiarities of an individual case can determine the point. In recent times, the tendency has increased more and more rather to attempt the conservation of the extremity in these doubtful cases than to amputate a limb which might possibly have been saved. We are justified in risking more because we are better able to meet the dangers which may eventually arise. The principle may no doubt be defended on general humanitarian grounds, but it cannot be denied that this conservative surgery of the limbs at the expense of life may be carried too far, and that we cannot deviate *all too far* with impunity from the principles of earlier experienced surgeons, who generally gave the preference to amputation in these doubtful cases. Besides the nature of the injury and the greater or slighter contusions combined with it, the significance of an individual case depends greatly also upon the circumstance whether we have to do with deep wounds and fractures situated deeply amongst the muscles, or with bones which lie more or less immediately under the skin, since the danger depends as much upon the depth as upon the extent of the injury to the bone. Thus the prognosis of an open fracture on the anterior surface of the leg will be more favorable than that of a similar injury to the forearm or upper arm. The most unfavorable are open fractures of the thigh, and there are surgeons whose experience has led them to conclude that it is better, in such cases, to amputate at once than to expose the patients to the risks of conservative treatment. This is, at the present standpoint of surgical therapeutics, decidedly wrong, although it may be convenient.

Laceration of larger branches of nerves in cases of fracture does not occur very often and appears, moreover, not to have any very essential influence as regards the cure. Experiments on animals, as well as experiences in man, show that the bones in paralyzed extremities may also heal normally. Injuries to the larger veins, e. g. to the femoral vein, cause hæmorrhages, which can, however, easily be controlled by a compressing dressing, but become dangerous if blood diffused in considerable quantity between the muscles and under the skin passes into a state of decomposition. The [illegible]tion of the main artery of an extremity [illegible] considerable arterial hæmorrhages; this does not necessarily cause,

however, since, as explained formerly, a thrombus is easily formed in contused arteries, so that much hæmorrhage does not always follow. But if we recognise from the nature of the hæmorrhage that an artery has been torn, we must in accordance with the principles already established, either attempt to tie the artery within the wound or the main branch at the *locus electionis*. Laceration of the femoral artery with concomitant fracture of the thigh always leads according to experience to gangrene, and is therefore, an absolute indication for primary amputation; in the case of a corresponding injury to the upper arm, an attempt to save it may succeed, but may also be frustrated by gangrene; healing of the forearm or leg may take place in spite of laceration of one or even both main arterial trunks.

Lastly, we have still to consider, with reference to the question of amputation, or an attempt to cure, how far, if we should succeed in overcoming all difficulties and effecting a cure, the healed extremity will be useful. This question may obtrude itself, especially with compound fractures of the foot and leg, and it has happened repeatedly that it was necessary to amputate feet which, when healed after open comminuted fractures, had assumed changes of form and positions which rendered them utterly useless for the purpose of locomotion. The same thing must also be taken into consideration when we would decide, in the case of moderately extensive gangrene of the foot, whether we shall amputate it or not. The separation of the dead parts of the foot may occur in such an unsuitable manner that the remaining stump is useless either for walking upon or for coaptation to an artificial limb. In such cases amputation is necessary; all our modes of amputation are calculated for the future adaptation of wooden legs or artificial limbs.

Since we have been led by the nature of the subject directly to the indication for amputation in case of injuries, I will here inform you at once how it stands with *secondary amputations* after injuries. In reference to the question whether amputation should be performed or not in a case of compound fracture, you might easily console yourselves with the idea that amputation might always be performed later on if your anxiety concerning an unfavorable course should be verified. In this respect, careful observation has shown that we must distinguish two moments from these secondary amputations. The first danger which threatens the patient is an acute process of decomposition in the neighbourhood of the wound and

the putrid blood-poisoning connected with it. It is decided by about the fourth day whether this danger is impending; if it has set in and you now amputate (which must always be done very high above the ichorous infiltration), that is the most unfavorable moment for the amputation, since we unfortunately only *very seldom* succeed in saving such a patient. Somewhat more favorable, although still very unfavorable in comparison with primary amputations (such as have been performed before the setting in of inflammation, therefore some time within the first forty-eight hours), are the results of amputations which you perform from about the eighth to the fourteenth day, on account of commencing acute suppurative infection (*pyæmia*).

If the patient has survived two or three weeks and the indication for amputation should then be given either by a very profuse, exhausting suppuration without rigors, with moderate fever, or by purely local reasons, the results may again be comparatively favorable if the powers of the patient have not already been very much reduced by suppuration and fever. If many surgeons have asserted that secondary amputations generally give better results than primary, they have almost exclusively had in their minds secondary amputations under these last mentioned circumstances. But if we consider how many patients with open fractures succumb within the first three weeks, how few, therefore, live until a time favorable for secondary amputation, I think there can be no doubt that primary amputations very decidedly deserve the preference whenever the indications for amputation immediately after the injury have been clear. I have, as yet, but very seldom met with indications for late secondary amputations.

The healing of an open fracture may occur in very different ways. It sometimes happens that both the wound in the skin and the fracture heal, without suppuration, by the first intention. This is certainly to be regarded as the most favorable case. With the modern methods of treatment this occurs more frequently, although the conditions required therefor are not often present. It happens much more frequently, and this is also to be regarded as very favorable, that the wound suppurates to a slight depth only, and that the suppuration does not extend between and around the broken ends of bone, but that the healing about the bone goes on as in a simple subcutaneous fracture. The cases in which the

wound affects the skin only, and does not communicate at all with the fracture, ought not to be reckoned as compound fractures at all; the boundaries are, however, very difficult to define.

If the skin wound be large, if the soft parts be much contused so that shreds hang from them, if the injury extend deeply between the muscles and the bones, or even into the medullary canal of the bone, if the fragments lie very obliquely to each other, if half loose pieces of bone exist here and there, if longitudinal fissures extend far into the bone, the healing process must differ in many respects from that without suppuration. The activity of the soft parts will remain essentially the same as in subcutaneous fractures with the exception that in this case the inflammatory new growth does not become callus directly, but that, after the separation of the contused necrosed shreds, granulations and suppuration occur, the former of which become converted into ossifying callus. The form of the callus will not vary essentially, except that when the open suppurating wound existed for a long time a gap will remain in the ring of callus until it becomes closed by the later granulations ossifying at the bottom of the wound. The process will, therefore, be completed much more slowly that in a subcutaneous fracture, just as healing by suppuration requires much more time than healing by the first intention.

But what becomes of the ends of bone which lie in the wound partly or entirely denuded of their periosteum? What becomes of larger or smaller pieces of bone completely separated from the main bone and attached loosely to the soft parts? Two possibilities exist here, as in the soft parts, according as the ends of bone are viable or dead. In the former, more frequent case, granulations grow directly from the surface of the bone. In the latter case, plastic activity ensues in the bone, as in the soft parts, at the confines of the living tissue. Interstitial granulations and pus are formed, the bone softens, the dead end of bone, the *sequestrum*, comes away. The extent to which this process of separation proceeds depends naturally upon the extent to which the circulation has been interrupted in the broken end of bone, or in the pieces broken off, in consequence of the closing of the vessels. This extent may vary greatly; it may go as far as the superficial layer of the injured bone only, and as we call the whole process of separation *necrosis*, so do we call this superficial separation of a layer of bone *necrosis superficialis*, while we may call the separation of the

entire broken end of a fracture *necrosis totalis*; the expression necrosis totalis is, however, more in use if we wish to say that the whole diaphysis of a cylindrical bone, or at least the greater part of it has come away; the opposite of this is *necrosis partialis*. The opposite of the above-mentioned necrosis superficialis, which is also spoken of as *exfoliation*, is, properly speaking, *necrosis centralis*, *i.e.* the process of separation of an inner portion of the bone. Necrosis superficialis and necrosis of the broken ends of bone as well as of the partially separated fragments of bone are so frequently combined with the suppurating fractures here in question that we could not do otherwise than speak of them now.

It will appear strange to you at first that luxuriant vascular granulations should spring from the hard smooth cortical substance of a cylindrical bone. From what you have been told already it will appear possible to you that the hard bony tissue should become dissolved under the influence of these plastic processes, and that a solution of continuity between the dead and living tissues may take place spontaneously. We will now follow these processes of *the formation of granulations in bone* and of *suppuration of bone* into their minuter details.

You will recall to mind, from the detailed description of the traumatic suppuration process in soft parts, that this process concentres chiefly, histologically, in a rapid and considerable dilatation of the vessels, and in a copious cell infiltration proceeding directly from the blood. The intercellular substance then becomes soft and very vascular and thus is formed the granular tissue, from which pus cells constantly make their appearance on the surface. These processes can develop themselves in the bone, especially in and about the firm cortical substance of a cylindrical bone, in a very small degree only, because the rigid bony substance prevents any considerable dilatation of the capillary vessels of the bone contained within the Haversian canals, as well as an excessive, acute cell-infiltration into the latter. I point out to you here at once that necrosis of individual portions of bone may occur much more easily with this slight capability of dilatation in the vessels within the bony canals than in the soft parts, because, if coagulations of blood occur, even in smaller capillary districts, nutrition can be equalised but very imperfectly through dilatation of the collateral capillaries, and extensive necrosis would occur much more frequently if the danger of stasis were not lessened by the many transverse anasto-

moses of the vessels of the bone. Necrosis may also occur in the course of suppuration if the connective tissue and the vessels in the Haversian canals *suppurate out entirely, i. e.* become so strongly infiltrated with pus that they lose their vitality and the circulation in the bone thus naturally ceases altogether. The development of a highly vascular granulation-tissue on the surface of the bone, or within the compact bony substance, is only possible, as already described, if the bony substance (salts of lime as well as organic matter) has previously disappeared at the points where new tissue is to take its place; resolution and removal of the bony tissue must take place under the same conditions as in the soft parts (compare Fig. 45). The difference shows itself chiefly in the difference of the time required; the development of granulations about and in the bone occurs much more slowly than in the soft parts. I mentioned before that the same process goes on much more slowly in the so little vascular tendons than in the connective tissue, the muscles, and the skin; in the bone it is still slower than in the tendons. Moreover, the vital energy of the whole individual and the consequent so-called degree of vitality of the tissues, must also be taken into consideration.

LECTURE XVI.

Development of granulations in bone. Histology.—Separation of sequestra. Histology.—New-formation of bone around the separated sequestra.—Callus in suppurating fractures.—Suppurative periostitis and osteomyelitis.—General conditions.—Fever.—Treatment; perforated dressings, closed, cut-open dressings.—Antiphlogistic means.—Immersion.—Lister's method.—Behaviour of splinters of bone.—After treatment.

If a completely exposed portion of bone is about to form granulations upon its surface (which we can, of course, only see in compound fractures when the ends of bone, *e. g.* on the anterior surface of the thigh, are full in sight), we recognise this with the naked eye by the following changes. The surface of the bone generally retains, in the first eight or ten days after being denuded of its periosteum, its yellowish colour, which passes in the last days of the period mentioned into a brightish pink. If we then examine the surface of the bone with a magnifying glass, we can already recognise a large number of fine, red points and stripes, which are also visible, a few days later, to the naked eye. These small points and stripes increase rapidly in size and grow in breadth and height until they become confluent, and then present a complete granular surface which unites directly with the granulations of the surrounding soft parts, and afterwards also takes part in the cicatrization, so that such a cicatrix adheres closely to the bone.

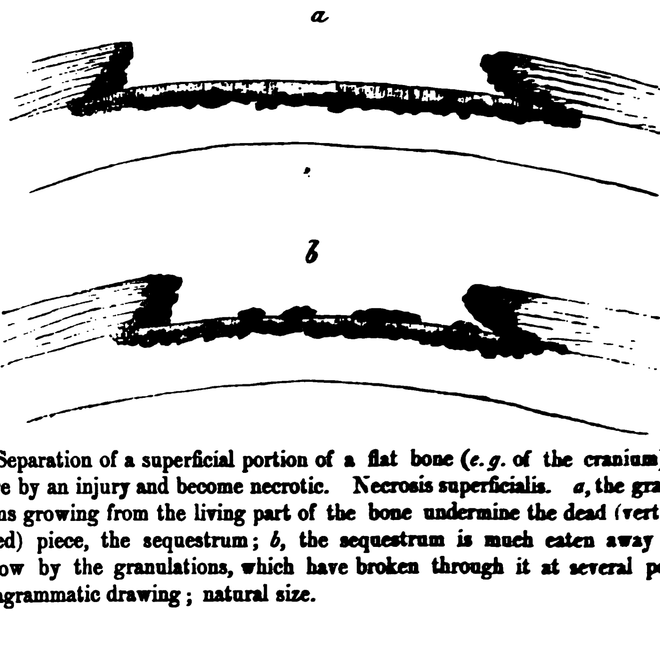
If we follow this process into its finer, histological details, which must be done chiefly experimentally with the aid of bones freed from chalk and injected, we arrive at the following results: if the circulation in the bone has been maintained almost to its surface, a copious infiltration of cells takes place in the connective-tissue which accompanies the vessels in the Haversian canals; this tissue then grows with the loops of vessels which first develop themselves from

the bone towards the surface at those points at which the Haversian canals open outwards. The development of these new granulation-masses sideways takes place at the expense of absorbed bony substance. If we macerate such a bone with surface-granulations, its surface will resemble that of worm-eaten wood; in the numerous small holes, which all communicate more or less with the Haversian canals, was situated the granular tissue of the fresh, living bone. The surface of the bone does not, however, remain in this state, but while these bone-granulations become condensed and cicatrised to connective tissue on their surface, they become ossified pretty quickly at the deeper points, so that, at the close of the whole healing process, the injured bone is not defective at its surface, but, on the contrary, appears thickened by external and internal deposit of new bony mass. You see that the conditions are here exactly the same as in the subcutaneous development of the inflammatory new growth. If you refer to fig. 55 and imagine the periosteum to have been removed from the surface of the bone, the new growth will spring (in the case before us as granulation) in a fungoid form from the Haversian canals. This will at once be more intelligible to you if we now examine more minutely the process of the separation of necrotic fragments of bone.

If we now recur to what observation with the naked eye has taught us, and assume that we have a portion of the cranium partly deprived of soft parts before us, we shall, in case no granulations, as described above, are growing from the bone, observe the following phenomena: while the surrounding parts and also the portions of the bone which have remained covered with periosteum have already formed copious granulations and are secreting pus, the dead portion of bone remains of a pure white colour, or assumes, perhaps, a grey or even blackish tint. It continues many weeks, often two months and more, in this condition; it is surrounded by the most exuberant granulations; cicatrisation has already commenced at the periphery of the wound, and one cannot yet at all see what will happen, since the surface of the bone perhaps still presents the same appearance in the sixth week as on the first day after the injury. Some day, at last, we feel the bone and find that it is moveable; after a few attempts, we succeed in inserting the point of a pair of forceps under its edge and raise up a thin plate of bone, under which we observe luxuriant granulations; the under surface of the plate of bones is very rough, as if worm-eaten. The healing process now

goes on rapidly. It is often long, of course, before such a cicatrix becomes durable and firm, so as to be able to resist all injuries, such as pressure and friction, but the healing process often terminates favorably. This is the process which we call *necrosis superficialis*, or exfoliation of a bone (fig. 60).

FIG. 60.



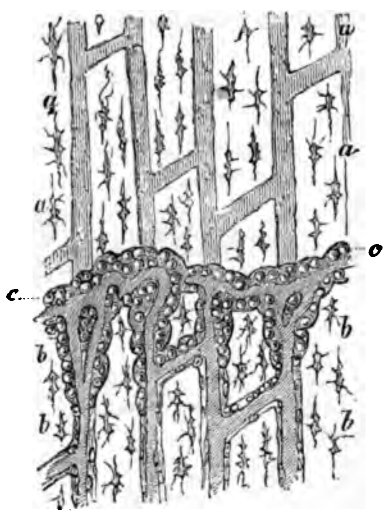
Separation of a superficial portion of a flat bone (*e.g.* of the cranium) laid bare by an injury and become necrotic. Necrosis superficialis. *a*, the granulations growing from the living part of the bone undermine the dead (vertically lined) piece, the sequestrum; *b*, the sequestrum is much eaten away from below by the granulations, which have broken through it at several points. Diagrammatic drawing; natural size.

We are already familiar with this process in the soft parts; large shreds of tissue hang from the contused wounds during the first week, while an interstitial development of granulations occurs at the border of the healthy parts and throws off the dead tissues; the process is the same here. These processes are easily investigated anatomically in bones deprived of their salts of lime. The inflammatory new-growth (the granular tissue) develops itself at the border of the sound parts in the Haversian canals. The following plate (fig. 61) will render this process intelligible to you in its histological details.

If you have rightly comprehended what I have just said, it will require only a very slight effort of imagination to picture to yourselves how the same process of separation of a piece of bone may

extend to the whole thickness of a bone, how, therefore, (and here we come back to compound fractures again), the broken end of a bone may, in a longer or shorter interval of time, become separated entirely if it is no longer viable. Such a process lasts many months if the thickness of the bone in question be very considerable, but we may eventually find even large pieces equally as loose in the wound as a superficial plate of bone and lift them out.

FIG. 61.



Separation of a necrotic portion of bone from the cortical layer of a cylindrical bone. Diagrammatic drawing. Magnified 300 times. *a*, necrotic portion of bone; *b*, living bone; *c*, new growth in the Haversian canals, by means of which the dead portion of bone is separated. Compare Fig. 39.

As regards the splinters of bone entirely broken off and connected with soft parts only, their further destiny depends upon the extent to which the circulation has been kept up in them, *i.e.* how far they are still viable. If they are quite dead, they become completely separated eventually by suppuration of the soft parts adhering to them and often keep up, as foreign bodies, irritation and copious suppuration of the wound. If they are still viable, they form granulations on their free surfaces which afterwards become ossified and unite with the general callus formed around the broken ends of bone.

To enable you to represent to yourselves how the callus-formation stands in relation to this process of separation, I have made the following diagram (fig. 62).

FIG. 62.

Fracture of a cylindrical bone with an external wound. Displacement and necrosis of both ends of bone. Longitudinal section. Diagrammatic drawing. Natural size. *e e*. Bone. *f f f f*. Soft parts of the extremity. *a a a a*. Necrotic ends of bone. The very darkly lined portion represents the granulations which line the cavity (*d*) opening outwards and secrete pus. *b b*. Internal callus in both somewhat displaced ends of bone. *c c*. External callus.

The fragments of the broken bone have not been re-adjusted exactly, but are displaced somewhat laterally. The ends of the fragments have both become necrotic, and are near separation by exuberant interstitial granulations at the border of the living bone. The whole wound is lined with granulations secreting pus, which passes out at (*d*). In both fragments, an internal callus (*b b*) has been formed, which has not coalesced everywhere, however, on account of the suppuration of the surfaces of fracture; the external callus (*c c*) is irregular and interrupted at (*d*), because the pus could escape outwards here from the first. Now, if the granulations grow so freely that they fill up the whole cavity and then become ossified, the healing process would thus be completed and the final result be exactly the same as in the case of subcutaneous fractures.

To render this possible, the necrotic ends of bone must be removed, for experience has shown that they cannot become enclosed in the bony cicatrix. This elimination of the sequestra takes place either by absorption, or by artificial removal outwards; *the former is more common with smaller, the latter with larger sequestra;* but so long as sequestra remain between the granulations of the fragments, the healing process will certainly not be completed. Since the opening at (*d*) may become very narrow from free development of the external callus, the artificial removal of the necrotic ends of bone may sometimes be very difficult. We ascertain by examination with a sound whether such sequestra exist at the bottom of the wound and whether they are loose. If you imagine the sequestra (*a a*) (fig. 62) removed from the cavity of the wound, no further obstacle exists to the filling up of the wound by granulations and to their consequent ossification. In compound fractures, such sequestra are very frequently the cause, not only of fresh exacerbations of the acute, suppurative inflammatory processes, but also of attacks of subcutaneous and chronic periostitis, with persistent, hard œdema of the extremity and troublesome eczematous eruptions on the skin of the latter, as well as of long-continuing bony fistulæ and ulcerative processes about the broken ends of bone. These sequestra have the double influence of a foreign body and of a sometimes more local, sometimes more general pus-infection.

FIG. 63.

Amputation-stump of thigh with necrosis of sawn surface.

We may here speak by the way *of the conditions obtaining about the bone after an amputation.* If you imagine fig. 62 cut across at the point of fracture and the lower half removed, the conditions would be the same as after an amputation. Either the bone now throws out granulations immediately from its wounded surface, or a piece of it (the sawn surface) becomes necrotic to a greater or less extent (fig. 63). However this may be, a new-growth (the half of a callus) will certainly be formed as well in the medullary canal as externally on the bone, and will eventually become ossified; if you examine an amputation-stump after some months,

you find the medullary canal closed by a bony mass, as well as thickened by external deposit. I may remark here that the name *callus* is used almost exclusively for the bony new-growth in cases of fracture, while the name of *osteophytes* is given to the bony new-growths which may form on the surface of the bones under the most varied circumstances; callus and osteophytes, therefore, do not differ essentially in any respect, being both of them expressions for new formations of bone.

There are two constituents of bone which we have left out of consideration, so far, when speaking of the process of suppuration, viz. the *periosteum* and the *medulla*. We have seen, when treating of the development of callus, that the periosteum also takes an active part in the formation of the new bony mass. If, however, the suppurative inflammation spreads considerably in open, suppurating fractures, in consequence of extensive contusion, a great portion of the periosteum may also partly become necrotic, and partly be destroyed by suppuration, and we find, in such cases, extensive *suppurative periostitis*; the greater part of a cylindrical bone, *e. g.* of the tibia, may be bathed in pus. The bone cut off from its connection with the surrounding soft parts is thus deprived of its supply of blood from the surface, and just in this way extensive necrosis of the bone may occur in consequence of the suppurative periostitis. These local dangers are, however, to be regarded as slight in comparison to those which such deep-seated suppurations bring with them for the whole organism, and which we shall have to speak of very much in detail later on.

Not less may the medulla of a cylindrical bone, as well as of a spongy portion of bone, take part in the suppuration. You know from what has already been said, that in the course of the normal healing process in fractures, new bone is formed in the medullary canal also, and that this canal remains closed thereby for a considerable time. In open, suppurating fractures, suppuration of the medulla also sometimes occurs, which may spread to a greater or less extent. Such a *suppurative osteomyelitis* is not less dangerous, as well for the existence of the bone as of the whole organism, than suppurative periostitis. Various causes may also give it an ichorous character; the larger veins of the bones which pass out of the medulla, may take part in the suppurative process, and this disease is the more dangerous in its consequences because it goes on at a great d[illegible] frequently, only be recognised with

certainty in the dead body. Suppurative osteomyelitis in itself also may lead to partial or even total necrosis of a bone, and still more if it is combined with suppurative periostitis.

Although it was necessary to make you acquainted with all the above-mentioned local complications of open fractures, I may relieve you by adding that it is only in rare cases that they occur to the extent described; neither total necrosis of both ends of the fracture, nor extensive purulent periostitis and osteomyelitis are necessary consequences of these fractures, but fortunately the deep parts often heal up in a very simple manner, and it is only externally that there is any long continuance of suppuration. Whether a traumatic inflammation leading to suppuration will extend beyond the borders of the irritation (the injury) depends in these cases, as in simple contused wounds, upon the kind and degree of the injury, and subsequently upon the presence or absence of all those conditions which we have learned to recognise as direct or indirect causes of secondary inflammation in wounds. The more extensively the bone is shattered (especially in gunshot-wounds) the more serious are all the immediate and mediate results of the injury.

Now a few words as to the general condition of the patient, especially as to the fever which attends complicated fractures. While in subcutaneous fractures it is to be regarded as a rare occurrence for fever to supervene, in open fractures on the other hand, it is only in exceptional cases that this condition is absent. If ever the fever obviously depends upon the extent and intensity of the local process, such dependence can be easily traced here. As we have already mentioned with regard to contused wounds, so in the cases before us, every extension of the inflammation is accompanied by an increase of fever, the severity of which, generally speaking, is in direct proportion to the depth to which the suppuration extends. In accidental osteomyelitis and periostitis the temperature of the body not unfrequently rises in the evening above 40 C. (104° Fah.); rapid and great increase of temperature associated with shivering is unfortunately a not unfrequent symptom; septicæmia and pyæmia, trismus and delirium potatorum are especially prone to accompany suppurating fractures, so that I can only repeat here what I have already observed at the commencement of the chapter, that in the majority of cases any open fracture may be or may become a severe and dangerous injury. Hence the greatest precautions and care are necessary. I can assure you from my own experience that the

most successful cure by operation has seldom given me such pleasure as the successful treatment of a severe complicated fracture.

Let us now pass on to the treatment of open fractures. The special advantages of firm immoveable dressings having become apparent during the last few years, it was natural that they should be adopted in modified forms in the treatment of open fractures; indeed, some time ago, Seutin, the inventor of the starch-bandage, brought into use the so-called "fenestrated" bandage, that is to say, he made an opening in the firm starch bandage, corresponding to the wound in the soft parts, so as to render this accessible to observation and treatment. The primitive forms of these fenestrated starch-bandages and of the plaster-bandages which are now very often used, were liable, certainly, to great objections, which, however, may now be considered as completely overcome. The principal objection to the fenestrated bandages was this, that the under-bandage and wadding which have to be applied under the starch- or plaster-bandage, were always very prone to become saturated with pus, which, finding its way among the various portions of the bandage, decomposed, and became offensive. Extensive experience has convinced me that these drawbacks can be overcome; it is only necessary to make the openings large enough, to round off the edges of the fenestra by applying strips of linen fastened by gypsum and collodion, to give sufficient firmness to the dressing by using Ris' position-splints, and by introducing wedges and strips of wood, and lastly, to catch the secretion of the wound in vessels placed underneath. If such a dressing remain firm and clean, the labour of its first application is repaid, not only by the brilliant success of this method of treatment, but also by the great saving of time in the subsequent care of the patient. For a long time in treating open fractures I have used the plaster-bandages almost exclusively in this way; I applied them first quite closed, as for a simple fracture, and immediately slit them up lengthwise, bent the margins somewhat asunder, and dressed the wound every two days, or daily as required, without disturbing the fragments, and continued this until the wound was healed; and then, in conclusion, when necessary, I applied a fresh and completely closed bandage, and kept it on for some time. This method is useful for some cases, and has been followed by good results. The essential thing in these various manipulations always is, that, after deciding not to ampu-

tate, even the most complicated fractures should be placed in the plaster-bandage immediately after the injury, just as we do with a simple fracture, only with this difference, that the wound should be covered with lint or compresses which have been previously dipped in Goulard-water, a solution of chloride of lime, or of carbolic acid, quantities of wadding (two fingers' breadth in thickness) having been placed on the extremity, before the dressing is applied, so that the limb may not become strangulated even if swelling should ensue.

When the wound is very great, or when there are several wounds at the same time, the difficulty of applying a firm bandage of any kind is, under all circumstances, very much increased. If in such cases there be extensive and deep-seated suppuration, so that numerous counter-openings are required and the number of the wounds thus considerably increased, it will be impossible to keep on the same dressings for any length of time, and we may then perhaps be compelled temporarily to return to splints and fracture boxes, which must be completely renewed every day. Severe cases of this kind, however, as you may infer from what has been said, come very near to those in which amputation is necessary, for generally speaking it is very doubtful whether union will take place. The more practice one has had in the application of the plaster-dressings, the less frequently will bad accidents occur. Since I have applied the dressings in the above manner to complicated fractures, diffuse septic inflammations and secondary suppurations come under my notice much less frequently than before. I am perfectly convinced that the treatment of open fractures with plaster-dressings is the best; but a surgeon must study this method, and not suppose that he knows it intuitively.

If a surgeon of the old school were to see our present treatment both of simple and complicated fractures, it would seem to him not only irrational, but also excessively fool-hardy, for, in by-gone days, fractures of bones, like every other injury, were treated with strict antiphlogistic measures, all other steps being regarded as secondary to these. It was therefore considered necessary to apply leeches to the broken limb in the neighbourhood of the fracture, to keep on cold compresses or bladders of ice, and to purge the patient freely. Subsequently, in open fractures, when the wounds began to suppurate, cataplasms were had recourse to, and these were continued until the healing was nearly complete. In addition to this a splint

was applied, and changed about every two or three days, while the wound was more or less frequently dressed, according to the amount of suppuration. Larrey was one of the first to protest against this frequent change of dressings in wounds in general and especially in open fractures. In more recent times the general opinion has been adopted that in the treatment of open fractures, as in that of subcutaneous ones, the first condition for the healing process to go on satisfactorily is that the fragments should be fixed as accurately as possible, and that nothing is more apt to excite inflammation around the wound than movements of the fragments. Firm coaptation of these latter is therefore the most important and efficacious antiphlogistic which we can employ in these cases. We here repeat a remark already made, that cold and abstraction of blood have no prophylactic antiphlogistic effects, as was formerly supposed. When I consider it necessary to apply ice round the wound on account of the supervention of progressive inflammation, I remove a portion of the plaster-dressing corresponding to the spot to which the bladder of ice is to be applied. Any suppuration that may take place anywhere about the wound must be dealt with by making incisions to facilitate the escape of the secretion. The general principles which guide us in choosing the places for incision are, that the counter-openings should be made where fluctuation is most distinctly to be felt, where there are the fewest soft parts to cut through, and where the pus will escape most readily without pressure from the finger. If we have to make openings in the bandage, this may be done most easily two and three hours after its application. After having made openings in the plaster-bandage corresponding to the wound, without thereby disturbing the limb, we separate the wadding, remove the lint, and bind the opening carefully; we then with a spatula push some wadding under the borders of the opening, so as to prevent the secretion from the wound from infiltrating into the dressing. For several years, in treating complicated fractures, I have been leaving all wounds and discharging abscesses quite open, and have been very much pleased at the successful results of this method. It is true that for the treatment of complicated fractures with plaster-dressings very careful manipulation and the knowledge of a large number of details, which can only be obtained at the bedside of the patient, are very requisite; the gift of inventing modifications of various forms of dressing is also necessary. The treatment of an open fracture is often extremely difficult; every

one employs in practice the method he has learnt; it matters not whether plaster, starch, or liquid-glass dressings be employed; the essential thing is that the fragments should remain fixed and at rest, and not be disturbed by the dressings; the patient will then be free from pain, and make a good recovery.

The favorable results of the treatment by immersion in contused wounds of the hand and foot have induced some surgeons to adopt the same treatment for complicated fractures, at least for those of the leg and forearm. For some years past, in the Berlin surgical clinic, attempts have been made to keep the fractured limb covered with a fenestrated plaster-bandage in a permanent water-bath; for this purpose the plaster must be made water-tight, by smearing it over with cement, solution of shellac, liquid glass, collodion, and the like. The results of this treatment are very highly spoken of. This method, however, appears to me quite unsuitable in cases where suppurative inflammations occur about the wound, and in which the continuous use of the water-bath is in itself injurious.

In the treatment of open fractures with splints, we generally use such as are straight and narrow, and made of wood, sheet iron, gutta-percha or some hollowed-out material; those, for the lower extremity, are furnished with a foot-piece. In the course of the last few years Lister's treatment has gained great repute, particularly for open fractures; all surgeons are unanimous in its praise. Before the application of the prescribed dressing, the wound and the parts adjoining are very carefully cleansed with a solution containing 3 per cent. of carbolic acid, the wound and all its crevices are thoroughly washed out with a solution containing 5 per cent. of zinc chloride, and thorough drainage is provided for; then the limb is fixed by means of a plaster-bandage if the wound is small, and by splints where the wound is large. Under this treatment the suppuration is but slight if decomposition of the secretion of the wound is successfully prevented, purulent periostitis and osteomyelitis are by no means prone to invade the broken ends of the bone, and thus the most serious cause of secondary necrosis is obviated. In the extremely small number of open fractures, which occur here in my clinic, I have not had an opportunity of giving an extensive trial to this method in these cases; I may, however, recommend it to you most earnestly.

We commenced our account of the treatment of complicated

fractures by describing the dressing, and I must now add a few words with regard to the first examination. The diagnosis of complicated fractures is made in the same way as that of simple ones. It is in many cases quite unnecessary and only injurious to introduce the fingers into the wound; it is only when we may expect that there are loose splinters of bone, as, for example, in gunshot fractures, or when we think we can feel splinters, or can see them, that we should attempt to draw these out; the less you find it requisite to examine the wound the better. All firmly adherent splinters of bone are allowed to remain; the sawing-off of pointed ends of fragments (primary resection of the fragments) may occasionally be desirable; I have only had occasion to do this when, even under chloroform, it was found impossible to replace and fix the fragments. The replacement of the fragments must be done in the most accurate manner before the application of the dressing, subsequent bending and pulling are decidedly to be avoided, and, if necessary on account of great dislocation, they should be postponed until the wound is healed. In like manner, it is quite improper and useless at this early period to attempt to detach by traction any semi-adherent splinters of bone; a piece of dead bone attached to the periosteum or other soft parts is gradually detached spontaneously, and then may be taken away. It occasionally happens that several weeks after the injury great swelling sets in, with profuse suppuration and violent fever; in such cases partial necrosis of sharp fragments may possibly be the exciting cause of the symptoms; we should then make an attempt under chloroform to remove the offending splinters. If there are no such definite causes for fresh examination of the wound, there is no need to use probes in order to discover dead splinters, until the wound becomes as free from irritation as a chronic bone fistula, and then the examination should be made with the greatest care and with very clean instruments. If there be an extensive necrosis of one or both fractured ends, the extraction of the dead portions of bone may present some difficulty; we should then have recourse to the same operation as for necrosis in general, of which we shall speak later on, when treating of diseases of the bones; this, however, should not be done until the process has passed into quite a chronic stage.

As regards the length of time required for the healing process of complicated fractures, this is always greater than for the simple varieties; indeed, in protracted suppuration it occasionally happens

that more than double the time is required as compared with simple fracture. We have to decide this by manual examination, and until the fracture is completely consolidated we should certainly not allow the patient to make attempts at walking. The disappearance of the callus, its condensation, its atrophy externally, and its absorption until the medullary cavity is restored, go on in just the same way as in simple subcutaneous fractures. The treatment of complicated fractures is one of the most difficult subjects in the whole of surgery; we are never too old to learn more about it.

LECTURE XVII.

APPENDIX TO CHAPTERS V AND VI.

1. *Retarded formation of callus and development of pseudarthrosis.—Causes often unknown.—Local conditions.— Constitutional causes.—Anatomical conditions.—Treatment; internal, operative measures; criticism of methods employed.*—2. *Obliquely-united fractures; rebreaking, bloody operations.—Abnormal development of callus.*

1. *Retarded development of callus and formation of a false joint, a so-called "pseudarthrosis."*

UNDER certain circumstances, which we do not always understand, a fracture treated in the usual manner does not become consolidated after the usual time has elapsed; indeed, it may not become consolidated at all, but the seat of fracture may remain perfectly painless and very movable, so that, as may be easily understood, the functions of the limb may be impaired to such a degree as to render the latter completely useless. A short time ago a strong peasant boy was admitted into hospital with simple subcutaneous fracture of the leg, without dislocation; a plaster-bandage was applied as usual and renewed in fourteen days' time. Six weeks after the fracture had occurred the whole of the dressing was removed, under the expectation that union of the bones had taken place; but the fractured spot was still perfectly movable, and no formation of callus could be felt externally. I here had recourse to the simplest means in such cases—I placed the patient under chloroform, and then rubbed the fragments forcibly together until crepitation could be very distinctly perceived; then I again applied a plaster-dressing, and on removing this in four weeks' time I found the fracture already tolerably firm. I placed the patient in a fracture box, and, without putting any

bandage on the leg, had its anterior surface painted over daily with strong tincture of iodine, a remedy which is sometimes successful even without any previous rubbing together of the fragments. After this had been continued for fourteen days I found that the fracture was perfectly firm; the patient now stood with the assistance of crutches, and a short time afterwards was discharged from hospital cured. Several cases have come under my notice in the practice of my colleagues, in which perfectly simple fractures in very healthy young persons did not become consolidated, but resulted in pseudarthrosis. Such occurrences are to be considered, as a general rule, very rare; usually there are some very definite causes, sometimes diseases of the bones, to account for the formation of a pseudarthrosis. Experience teaches us that there are certain fractures of the human skeleton which for various reasons scarcely ever become united by bony callus; among these are the intracapsular fractures of the neck of the femur and neck of the humerus, and fractures of the olecranon and the patella. When broken transversely the two last-named bones separate so far that the bony substance formed by both ends cannot meet, so that only a cicatricial ligamentous union can take place between the portions. The head of the femur, if fractured within the capsule, still has, it is true, a supply of blood through a small artery which enters it through the ligamentum teres, but this source of nutrition is very slight, and consequently the production of bone from the small fragment is very inconsiderable. In a fracture of the head of the humerus within the capsule of the joint, if the rare case should occur that a piece of the head is completely detached from the rest of the bone, this portion will receive no supply of blood, and will therefore act as a foreign body in the organism, and its union can scarcely be expected. In the above examples we consider non-union to be so much the rule that, generally speaking, we do not describe such cases as instances of pseudarthrosis. I mention, however, these cases in order to show you that there may be purely local causes predisposing to pseudarthrosis; among these there is especially the complete loss of large portions of bone, after the removal of which in open fractures a defect may exist so large as not to be again completely filled up by newly formed bone-tissue. Very protracted suppuration with ulcerative destruction and extensive detachment of the ends of fragments may likewise give rise to pseudarthrosis. Moreover, the treatment is occasionally blamed as the cause; too loose a dressing

or none at all, movement made too soon, are causes which may demand consideration. It has also been asserted that the too prolonged application of intense cold, the simultaneous ligation of large arterial trunks, and, lastly, a dressing too tightly applied, are all of them obstacles to the development of a sufficient amount of bony callus. All these, however, are in themselves by no means necessary conditions for the formation of pseudarthrosis, but they may contribute as secondary causes in patients whose organism, owing to the general state of the nutrition, is predisposed to the formation of pseudarthrosis after fracture.

Among the general predispositions and diseases of bone the following may be mentioned as predisposing to pseudarthrosis—a very low state of the nutrition; debility resulting from repeated losses of blood; specific diseases of the blood, such as scorbutus or intense cancerous cachexia. Of the diseases of the bones it is chiefly the osteomalacia, atrophy of the cortical substance, with enlargement of the medullary cavity, in which, as before mentioned, there is in certain stages not only considerable fragilitas ossium, but also very slight chance of reunion after fracture. I have stated all this to you because of its pretty general acceptation, although on minute critical examination some of the above-mentioned predisposing causes of pseudarthrosis appear to be of very doubtful value, while the significance of others has been well established. In the same way it is, among other things, a wide-spread belief that fractures do not become consolidated in pregnant women. This does not hold good in all cases; I myself have seen numerous fractures completely unite in pregnant women; in one case only the hardening of the callus was delayed a few weeks in a fracture of the lower end of the radius, which was recognised late, but this may also occur in non-pregnant women and in men.

The abnormal variety of the healing process, when pseudarthrosis occurs, does not depend upon the non-occurrence of any new formation, but on the failure of ossification in this latter. The substance connecting the fragments together becomes a more or less rigid connective tissue, by which the ends of the bone are held more or less closely together according to the distance between them. If the fragments lie so close to each other as to come in contact and rub together when the limb is moved, a cavity, with smooth walls and filled with a little sero-mucous fluid, forms between them in the connecting tissue; in some cases also cartilage has been found on

the fractured ends, so that, in fact, a kind of new joint had become developed. This, however, does not occur so very frequently, but in the majority of cases there is only a firm connecting substance, which sinks directly into the fragments like a tendon. The disturbance of function is always bearable when a pseudarthrosis of this kind exists in small bones, as, for example, in the clavicle, or even in one of the bones of the forearm, either the radius or the ulna; but if the separation occurs in the arm, leg, or thigh, there will, as a matter of course, be considerable impairment of function. In many cases we are able to give the necessary firmness to the limb by suitable supporting apparatus; in other cases we cannot succeed in doing this or can only give very partial relief, so that for some time past attempts have been made to cure pseudarthrosis by operation—that is, to induce ossification. Before we enter upon the description of the methods adopted for this purpose, we must mention the attempts that have been made both to prevent pseudarthrosis by internal remedies, when from any of the above-mentioned reasons it seemed likely to occur, and also to cure it when once established. Preparations of lime have been principally used for this purpose. Phosphate of lime was given internally in the form of powders, or lime-water mixed with milk was administered, but without producing any beneficial results. Of the lime introduced into the system in this manner but very little is absorbed, and of this superfluous lime taken, perhaps, into the blood, much is excreted by the kidneys, so that scarcely any benefit results to the pseudarthrosis. More, at any rate, may be expected from general regulation of diet and from nutrient materials which contain much lime; we shall return to this by and by when treating of rickets. Residence in good country air, and milk diet, are to be recommended, but you must not expect too much from these measures, certainly nothing in the case of a fully formed false joint which has existed for some years. In an interesting work lately published by Wegner, an extended series of experiments show that the continuous administration of very small doses of phosphorus causes the callus formation around fractures to become particularly abundant and firm, and also that when phosphorus is administered to growing animals the newly-formed bony tissue becomes extraordinarily firm and hard, and particularly rich in lime salts. These experiments strongly induce us to try phosphorus for patients with false joints, especially in the earlier stages. As a matter of course the greatest precaution and most careful

attention in regard to any possible secondary injurious effects are necessary in employing a remedy which is so dangerous when carelessly used. The local remedies all aim at inducing inflammation in the ends of the bone and parts around, because experience teaches us that the majority of inflammatory processes in the bones and neighbouring parts induce formation of osseous material, and that this is especially the case in subcutaneous changes of a traumatic origin. The means which are usually employed differ very greatly.

The removal of bandages and dressings from the limb, in order not to prevent the development of the external callus by any possible pressure or obstruction of the circulation due to our applications, the rubbing together of the fragments and painting with tincture of iodine, have been already alluded to. Blistering plaster and the hot iron to the skin of the part of the limb corresponding to the fracture are also employed as indirect means of irritating the fragments. By the following remedies we act more directly upon the ligamentous connecting substance :—Long, thin, acupuncture needles are passed into the connective ligamentous tissue between the fragments and left there for a few days to set up irritation; we may also connect the free ends of two of these needles with the poles of a galvanic battery and pass an electrical current by way of an irritant through the connecting bands of the fragments. This procedure is called "electro-puncture;" it is but little used, but it has answered in some cases. We may also introduce a small, thin tape, or several threads of silk twisted together, a so-called seton, or a strong ligature through the new-formed substance, and allow these cords to remain until copious suppuration has set in around them. The operations which now follow, and which are very numerous, deal more directly with the bones. For instance, a thin, narrow, but strong knife is passed down to the fracture, and then, without enlarging the wound in the skin, the ligamentous tissue is shaved with the point of the knife, first from one bony fragment, and then from the other. This is called "subcutaneous bloody freshening" of the fragments. Besides this we may make an incision down to the bones, dissect out both fragments, perforate them close to the fracture, and pass a sufficiently thick lead wire through the holes thus made; the ends of the wire are then twisted together so as to bring the fragments into close apposition. We may also, after having made an incision as before, saw off a thin ece from each fragment, and treat the wound thus made as an

open fracture, and this operation—resection of the fragments—may, in addition, be modified by the application of the suture to the bones. Dieffenbach is the originator of the following operation:—He makes two small incisions down to the bone and corresponding to the fragments, which he then perforates close to the margins, and then with a hammer drives ivory pegs of suitable thickness into the perforations. The result is that a new formation of young bony tissue takes place around these foreign bodies in the bones, and this, when sufficiently abundant, as it may at any rate be sometimes made by repeating this operation as time goes on, is enough to cause firm union. I may here mention that these ivory pegs, when extracted after a few weeks, look rough and, as it were, corroded at the points where they have been in contact with the bone, while the cavities in which they lay are almost completely filled up with granulations; sometimes the pegs are suffered to remain in, and the openings through which they have been introduced heal up over them. This proves absolutely that dead bone-substance, which ivory really is, may be dissolved and absorbed by the growing osseous granulations. We shall hereafter have frequent occasion to return to this formerly much contested question, which is one of great importance in many diseases of bone; the supposed causes of this absorption have been already alluded to (p. 253). B. v. Langenbeck has modified this operation of Dieffenbach by using for the purpose metal screws instead of ivory pegs; immediately after the operation he fastens these screws by means of a bar of steel to a connecting apparatus, which keeps the fragments firmly together. Whichever of all these methods may be adopted, suitable dressings must sooner or later be also applied in order to give firm support to the fragments.

The methods of operation in pseudarthrosis, of which I have mentioned only the principal ones, are, as you see, very numerous, and if the beneficial results corresponded to the number of remedies, pseudarthrosis would belong to the most curable class of diseases. But both in medicine and surgery you may generally take it for granted that the value of the remedies for any given disease is in decidedly inverse proportion to their number, and this holds good of the case before us. Some cases of pseudarthrosis admit of easy and certain cure, others are very intractable, and of the various methods at our command not all of them are adapted to similar cases. The operations, in the first place, vary as greatly as to the

danger involved, those on limbs with very thick soft parts, particularly in the thigh, being much more dangerous than on other parts; besides this, as may be readily supposed, the non-bloody operations are always less dangerous than those which cause bleeding, and those with small wounds much less dangerous than those with large ones. As regards efficiency and certainty, I consider that the application of a bone-suture and resection give relatively the quickest results even in the worst cases; but these operations are certainly attended by all the elements of danger of fractures complicated by wounds. The treatment with ivory pegs is less dangerous, except in the thigh, a part in which every operation for pseudarthrosis is hazardous, and would, I think, in most cases accomplish the object if the operation were repeated sufficiently often. The treatment of these cases may extend over half a year, or even longer. I myself have seen good results follow from this treatment, as also from the application of sutures to the bones. It is true that there are some cases in which, from causes unknown, the bones always become soft after intense irritation, instead of hardening and forming osteophytes; pseudarthroses in such individuals are incurable.

In pseudarthroses of the thigh the question may seriously be asked, whether we should not prefer amputation at the false joint, the prognosis of which in these cases is favorable, to any other dangerous and doubtful operation. This question can only be decided by the peculiarities of the individual case. In some cases a suitable splint apparatus is preferable to any operation.

2. *Obliquely-united fractures.*

Although with the progress made in the treatment of fractures, it nowadays rarely occurs that union takes place in so oblique a direction as to completely destroy the function of a limb, still, from time to time, we meet with cases in which, in spite of the greatest care on the part of the surgeon, displacement cannot be avoided, or else from carelessness or very great restlessness of the patient, or loose application of the dressings, &c., a considerable obliquity in the position of the fragments is found to remain. In many cases this is so slight that the patients are satisfied to allow the deformity to remain; an improvement in the position is desired

only in cases where, from considerable obliquity or shortening of a foot or hand, the movements are decidedly impaired. We possess a number of means by which these deformities may be greatly improved, and even quite got rid of. If, during the process of union, we notice that the fragments are not accurately adjusted, we may in simple subcutaneous fractures endeavour at any time to bring them into position. If, in an open fracture, obliquity of the fragments has occurred during the first dressing, I strongly advise you not to manipulate it with a view to forcible rectification before the wound has healed; you would thus break up the deeper granulations, and the most violent inflammation might be again excited. In fractures with long-continued suppuration the callus remains soft for some time, so that you may always subsequently produce a gradual improvement in position by splints suitably padded, first in one place, then in another, or perhaps by continued extension by means of weights. If the fracture be firmly consolidated in an oblique position, we may adopt the following means for its improvement:

1. We may rectify it by bending the callus, by infraction; we place the patient under chloroform, and attempt to bend the limb with the hands at the point of fracture; if our efforts are successful, we apply a firm dressing to the limb in its newly improved position. This perfectly safe method can only be successful when the callus is sufficiently soft to admit of being bent; it is therefore only during a certain time after the fracture that it is available.

2. Complete breaking up of the ossified callus. This may also be sometimes done by the force of the hands alone, but frequently we are obliged to have recourse to other mechanical aids. Various forms of apparatus have been constructed for this purpose, such as lever and screw machines of considerable power; one of these bears the terrible name of "Dysmorphosteopalinklastes"! All these apparatus require to be used with the greatest care, in order to avoid too great bruising and mortification of the skin by too violent pressure on the spot where the machine acts or where the limb rests. Many surgeons look upon these instruments as very objectionable, but this they are not. I have twice used, with very favorable results, Rizzoli's osteoklast in old obliquely-united fractures of the leg.

3. For the obliquely-united fractures of the leg, which are of more frequent occcurrence, forcible extension has been employed by A. Wagner with very favorable results. He uses the apparatus of

Schneider and Menel, which we also employ for reducing old dislocations. The mechanical effects of such an extension will be easily understood by the following illustration:—Take a moderately bent rod, let a strong man take hold of each end and pull, the rod will then break, frequently at the spot where it is most bent. A new fracture of the thigh having been thus produced at the bent spot by indirect force, and the fragments adjusted in a straight position, a plaster bandage is then at once applied while the limb is still kept extended by the apparatus. As far as our present experience goes this method appears to be thoroughly free from danger, but only to be adapted for the thigh. In one case in which a fracture of the leg was united at a very oblique angle I recommended this method, but the extension produced a fracture, not on the old spot, but close beside it.

4. The bloody operations on the bone are more serious, although when performed on the leg they are much less dangerous than was formerly supposed. Of these there are two; the first is the subcutaneous osteotomy of B. von Langenbeck. This consists in making a small incision down to the bone corresponding to the bent spot, introducing a medium-sized gimlet through this opening, and perforating the bones, without, however, making an opening through the soft parts on the opposite side. The perforator is then withdrawn, and through the perforation a small fine saw is passed; with this the bone is sawn transversely, first on one side, then on the other, until the rest of the bone can be broken through with the hand; now the bones are to be placed in a straight position, and the injury treated as a complicated fracture. This operation has hitherto only been performed on the leg, but, so far as I know, always with good results. It can also be performed in this way, by not making the adjustment until suppuration has set in, and the callus thereby become softened and partly absorbed; also instead of v. Langenbeck's instruments and apparatus, we may with advantage follow Gross's recommendation, and use a fine chisel to separate the callus from a small exposed portion of the bone. Even on the thigh the chisel has thus been repeatedly used in the performance of osteotomy with favorable results.

5. Lastly, we may also employ Rhea Barton's method, which consists in exposing the bone by a free incision through the skin corresponding to the spot where oblique union has taken place. A wedge-shaped piece is then sawn out of the bone in such a way that

the broad end of the wedge corresponds to the convexity and its apex to the concavity of the abnormal curvature. This method has also exhibited favorable results.

On the whole, the non-bloody methods, if they do not necessitate too much contusion, are to be preferred to those which cause bleeding.

If the deformity, especially of a foot, be so great in different directions that none of the above-mentioned methods offers sufficient prospect of cure, we may, in some cases, even be obliged to have recourse to amputation.

We meet with a few cases in which the callus is altogether abnormally thick and extensive, just as occurs in cicatrices of the skin and nerves. We must not resort too hastily to operations in such cases, for a slow subsequent absorption usually takes place in all callus. The removal of such masses of callus could only be effected with chisel or saw. I should, however, be unwilling to decide on such an operation.

CHAPTER VII.

INJURIES OF THE JOINTS.

Contusion.—Distortion.—Massage (Shampooing).—Opening of the Joints and Acute Traumatic Articular Inflammation.—Varieties of Course and Terminations.—Treatment.—Anatomical Changes.

Hitherto we have for the most part been considering the injuries of simple tissue-elements; we must now turn our attention to the more complicated apparatus of the body.

The joints, as is well known, are composed of two extremities of bone covered with cartilage; of a sac, the synovial membrane, classed among the serous membranes, and frequently containing many appendages, pouches, and folds; and of the fibrous capsule of the joints, with its supporting ligaments. Under some circumstances, diseases of the joints affect all these parts, so that at the same time we may have to deal with disease of a serous membrane, of a

fibrous capsule, as well as of cartilage and bone. The degree in which these various structures participate in the disease varies exceedingly in intensity and extent, but I may here remark that the synovial membrane and the bones play the most important part in the severe forms of joint-diseases, and that many peculiarities of these affections are principally due to the closed state and irregular form of the synovial sac.

In the first place, a few words about bruising or contusion of the joints. If a man receives a violent blow on a joint, extreme pain and moderate swelling may ensue; but in most cases both these symptoms will subside, and the normal function of the joint become re-established after a few days of rest and treatment with applications of Goulard water or even simple cold water. In other cases slight pain and stiffness remain; a chronic inflammatory process becomes set up, which may subsequently lead to severe disease, but of this we will not at present speak more fully. When we have an opportunity of examining a joint which has been somewhat contused, for instance in a case where a patient has died from serious injury of some other portion of the body received at the same time, we shall find more or less blood extravasated in the synovial membrane, or even in the cavity of the joint itself. In these contusions without fracture these effusions of blood are rarely so extensive as to cause the cavity of the joint to be tightly distended; this, however, may occur. This condition is called "Hæmarthron" (from αἷμα, blood, and ἄρθρον, a joint). If a joint that has become much swollen immediately after the injury remains painful for a long time, and feels hot to the touch, a somewhat more active antiphlogistic treatment is indicated. The joint should be uniformly covered with a wet bandage, which causes moderate compression; if the pain is very great and the extravasation considerable, a bladder of ice should be applied to the joint. As a general rule, inflammatory processes of this grade are readily subdued by such measures as these, although chronic diseases and a certain irritability of the joint that has been injured not unfrequently follow. It is very important to determine whether the contusion of the joint is or is not associated with a fracture or fissure of the ends of the bones; if these complications exist, a plaster-dressing should be applied, and the prognosis as to the future usefulness of the limb should be given with reserve, due regard being had to the kind of injury. Our prognosis as to whether the function of the joint will be sooner or

later restored greatly depends upon the presence or absence of injury to the bones, and the extent to which this has occurred. In many patients after these injuries the pain increases under the prolonged application of cold; we may then rub in or paint the part over with the Unguentum cinereum, and apply warm and moist compresses covered with gutta-percha tissue and wadding.

A form of injury peculiar to joints is *distortion* (literally, twisting). This is an injury to which the foot is particularly liable; people usually say that they have given their foot "a twist." A distortion of this kind, which, however, may occur in almost any joint, consists essentially in a tension, too great stretching, and even partial rupture of the capsular ligaments with escape of some amount of blood into the joint and surrounding tissues. The injury may at the time be very painful, and its consequences not unfrequently are excessively tedious, especially when the treatment is not properly conducted. In these cases, abstraction of blood and cold are commonly employed, but with only temporary benefit. It is far more important to keep the limb perfectly at rest after such injuries, so that any of the ligaments which have been torn may heal and acquire their normal firmness. The simplest way of obtaining this object is to apply a firm dressing, such as a plaster-bandage, with which we may allow the patient to go about, if this causes him no pain. After ten, twelve, or fourteen days, according to the severity of the injury, we may remove the bandage, but it should at once be reapplied if the patient has pain on walking. It may sometimes be necessary to keep such a bandage on for three or four weeks. This seems a very long period of treatment for such an injury, but I assure you that without the application of a firm dressing the consequences of these injuries often continue for several months, and in this way the danger of subsequent chronic inflammation of the joint is much increased. Your prognosis, therefore, must not be too favorable as to a rapid cure of these sprains, and the treatment of these often apparently insignificant injuries must be scrupulously and carefully conducted.

Rubbing the joint and kneading the extravasated blood, immediately after the injury, are measures which have been very highly lauded by many surgeons; these are old popular remedies which were employed even by the Greek gymnasts. This method of treatment is now called massage, which means rubbing and kneading (shampooing). Wonderful stories are told of the effect of this

method, particularly as regards rapid absorption of effusions and speedy restoration of function. In the first four or six hours after the injury the resolvent effects of the massage are certainly most marked; later on, when acute inflammation has set in, I should be less inclined to advise it, but we may persevere with it energetically, when the acute inflammatory swelling has subsided.

Unfortunately it pretty frequently happens that, even if sprains are treated with the greatest care, chronic inflammations result; these are not only troublesome by reason of their obstinacy, but slowly and gradually in the course of years lead to destruction of the joint; this occurs not unfrequently, especially in children and badly developed persons of a scrofulous or tuberculous diathesis. We shall subsequently return to these cases when discussing the etiology of chronic inflammations.

Openings of the Joints, and Acute Traumatic Articular Inflammation.

We now pass to wounds of the joints—a class of injuries very much more important than those which we have just now considered. While contusions and sprains of the joints are scarcely noticed by many patients, the opening of the synovial sac with escape of synovia, even if the wound be not large, is always a severe injury, often interfering with the function of the joint, and not unfrequently dangerous to life. The difference between subcutaneous traumatic inflammations and those which open externally, to which we alluded when speaking of contusions, is here again an important point to be considered, just as was the case in the difference between subcutaneous and open fractures. But besides this, we have in the joints to deal with irregularly-shaped, closed sacs, in which the pus once formed remains, and where also the inflammation of the serous membranes in an acute form has often a very injurious effect on the general condition of the patient, and even in more favorable cases may result in very tedious processes.

We are now speaking only of simple punctured or incised wounds, such as are done with sharp instruments, without any additional complications from sprains or fractures, and we choose as our example the knee-joint, with regard to which we remark that injuries to this joint are, generally speaking, regarded as the most

serious of those we are at present considering. I think that the quickest way to describe the process will be to give you a case as an example. A man comes to you, who, in cutting wood, has given himself a wound near the patella, half an inch long, and which has bled but little. This may have happened some hours before, or even on the previous day. The patient thinks little of the injury, and only wants to know from you how it ought to be dressed. You examine the wound, and find that from its position it corresponds to the capsule of the knee-joint, and around it you may see, perhaps, a little serous, slightly mucous, clear fluid, which escapes in greater quantity when the joint is moved. This will cause your attention to be particularly directed to the injury. You examine the patient, and learn from him that there was not very much bleeding immediately after the injury, but that some fluid, like fresh white of egg, escaped from the wound. In such a case you may be certain that the cavity of the joint has been opened, for otherwise the synovia could not have escaped. In small joints the escape of synovia is certainly so slight as to be scarcely noticeable; hence, in injuries of the small joints of the fingers, and even in those of the foot, elbow, and hand, it may for some time be doubtful whether the wound has penetrated the joint or not. When it is certain, or at least extremely probable, that the joint has been penetrated, the following measures should be at once adopted:—The patient must be put to bed and kept quiet, and the wound brought together as quickly as possible; hence the wound of the skin, when it has a tendency to gape, is best closed by neatly-applied sutures; for some small wounds of this kind carefully applied sticking plaster is sufficient, or isinglass-plaster painted over with collodion. It is now necessary to keep the joint absolutely quiet; for this purpose, wet bandages should be uniformly and tightly applied to the limb from below upwards; and it is also necessary that the whole limb should be securely and firmly fixed in an extended position on a hollow splint, or between two bags of sand. In most text-books on surgery you will, it is true, find it stated that you ought to put on a number of leeches, and to keep an ice-bag constantly applied in order to ward off too much inflammation. But I can assure you that local abstractions of blood and the application of cold do not possess this prophylactic, antiphlogistic power, and that it is time enough to have recourse to ice at a somewhat later stage. I have no objection, however, to apply ice to

injuries of the joints from the very commencement, indeed, I rather recommend this practice, lest the right moment for its adoption be allowed to pass by. I have also made use of the plaster-bandage instead of the above dressing; I apply it, as for a fracture of the knee-joint, from the foot to above the middle of the thigh with a position-splint, then cut an opening corresponding to the wound and the anterior surface of the knee-joint. The results of this treatment, as compared with that of the old regular antiphlogistic remedies without a firm bandage, are very striking. Let us return to our patient. You will find that on the third or fourth day he will complain a little of painful tension about the joint, and will be slightly feverish; on applying the hand, the joint feels warmer than the healthy one. By the fifth or sixth day you will have removed the sutures from the wound, and during the two subsequent days the course of events may be in one of two very different directions. Let us first take the most favorable case, which frequently happens under early treatment with firm dressings: the wound will heal entirely by first intention, the slight swelling and pain in the joint will diminish during the next few days, and finally completely disappear. If you remove the dressing in three or four weeks' time, the joint will be again moveable, and complete recovery ensues.

In other cases, however, especially if the patient comes under treatment late, the case takes a worse turn. Towards the end of the first week after the injury, not only does the joint become much swollen and very hot, but œdema of the leg sets in; the patient complains of severe pain on being touched, and at every attempt at motion; he becomes more feverish, especially towards evening; loses his appetite, and begins to emaciate. At the same time the wound may be healed by primary intention, or first a sero-mucous, and then purulent secretion escapes from it. But even should this not occur, the above symptoms—namely, the swelling of the joint with distinct fluctuation, the great pain, the increased temperature, the œdema of the leg, the increased fever—all point to acute, somewhat intense inflammation of the joint. If in such cases the limb be not fixed, it gradually assumes a flexed position, which, in the knee-joint, may increase to quite an acute angle. It is not altogether easy to give a reason for this flexed position of inflamed joints; but it seems to me most likely that it results from reflex action, the irritation of the sensory nerves of the inflamed synovial membrane being principally conveyed to the motor nerves of the

flexor muscles. Another explanation is, that every joint is capable of containing more fluid in a flexed than in an extended position. Bonnet proved this experimentally by injecting fluids into joints, in so far as he found that after he had injected fluid into joints of the dead body, they were usually brought into a flexed position. These experiments, however, do not seem to me to prove anything as regards the flexed position we are considering, inasmuch as it also occurs in inflammation of joints where there is certainly no accumulation of fluid; and, on the other hand, it is frequently absent where the quantity of fluid in the joint is very great. Observation, at any rate, teaches us positively that acute painful synovitis generally produces a flexed position of the affected joint.

If the above symptoms have appeared, the antiphlogistic remedies reassert their formerly approved claim; but we must not forget that in addition to this the position of the joint must not be neglected, so that in the event of absolute stiffness ensuing, this may occur in the position relatively most favorable for the function of the joint; for example, the knee-joint should be completely extended, while a right-angle position is suitable for the foot and elbow-joints. If attention to this point was neglected at the commencement of the treatment, the error must be corrected by placing the patient under chloroform, so that the affected limb may be placed without difficulty in the proper position. Among the antiphlogistic remedies under such circumstances, I attach most importance to the application of one or more bladders of ice upon the inflamed joint, and painting it over with tincture of iodine.

If the fluid in the joint increases very rapidly, and the tension becomes unbearable by the patient, there is imminent risk of ulceration of the capsule proceeding from within, and escape of the pus into the cellular tissue if it has no free exit through the reopened wound; we may then carefully draw off the fluid with a trocar, taking, of course, proper precautions against the entrance of air into the cavity of the joint. This tapping of the joint, which has been especially recommended for such cases by R. Volkmann, I formerly used with good results, and by its means cured, as I believe, four successive cases of severe, acute, traumatic inflammation of the knee-joint, with complete restoration of mobility. Since I have applied the plaster-bandage to simple penetrating wounds of joints, I have not, it is true, had recourse to tapping. The patient requires none of the so-called internal antiphlogistic remedies; if he

cannot sleep at night on account of the pain, we may give him small doses of morphia in the evening. By these means we may succeed in cutting short the acuteness of the process even in this stage; but even then the function of the joint may not be fully restored, although this may be possible if the suppuration of the synovial membrane remains chiefly superficial, (in the catarrhal stage). Frequently, however, the disease passes from the acute to a chronic course, the suppuration extends more deeply into the tissues, and more or less stiffness will then remain after recovery.

But, unfortunately, the inflammation, and particularly the formation of pus in and about the joint, sometimes extend uncontrollably. All we can do then is to dilate the wound, to make new openings in various places, to introduce drainage-tubes, carefully to syringe out all the cavities of the wound—in a word, to provide as completely as possible for the free and continuous escape of the pus, and at the same time to keep the joint fixed and at rest. When these bad symptoms occur, we have what is called "panarthritis," and the result is complete suppuration and destruction of the synovial sac. All the communicating synovial sacs do not always participate equally in the suppuration; it may happen that on tapping one portion of the joint, serum may escape, at another, pus; this is probably because the swollen synovial membrane closes, like a valve, the openings of communication, often narrow, which lead from the cavity of the joint to the adjacent sacs. In bad cases the suppuration extends to the soft parts of the thigh and leg, and the patient becomes thereby more and more exhausted, as also by violent attacks of shivering and fever; his face becomes pinched, and we are rather at a loss for any further remedies. Recovery is possible, however, even in this stage; the acute suppuration at last ceases, and the disease becomes chronic, and may so end after some months, usually with complete stiffness of the joint. In many cases we endeavour in vain to keep up the strength of the patient by means of tonics and strengthening remedies; he dies completely exhausted in consequence of the repeatedly recurring suppuration, which may even occur at points unconnected with the wound. This unfortunate termination can only be prevented by amputation, a sad remedy, but one which sometimes saves life in these cases. The difficulty here lies in the right choice of the time for operative interference; observations at the bedside, which you will make in the wards, must teach you how far you may venture to trust the

strength of your patients in individual cases, so that you may determine when the last moment for amputation has arrived. In hospitals you will constantly see many such cases die of purulent infection (pyæmia), whether amputation has been performed or not. Lister's method has also been much lauded for the treatment of wounds of the joints. In all but very simple cases we are recommended to introduce a drainage-tube immediately after the injury, to use an injection containing 3 per cent. of carbolic acid, to disinfect the wound, as far as possible, if the secretion has already begun to decompose, and to conduct the subsequent treatment under the use of the spray-apparatus. This treatment should certainly be pursued from the very commencement in cases where blood has been effused into the joint; if purulent decomposition has already set in, the drainage must be more completely provided for, and more often repeated, so that the cavity of the joint may be thoroughly disinfected.

In describing traumatic articular inflammation, we have confined ourselves to giving you a special case by way of example, and have detailed the symptoms and appropriate treatment; we must therefore now add a few remarks with regard to the pathological anatomy as it has been very minutely studied on the dead body, on amputated limbs, and by aid of experiments. The disease affects chiefly, we may say, indeed, at first exclusively, the synovial membrane. If, on dissection, this has not been carefully examined, as I know from my own experience, it is apt to be regarded as far too thin and delicate a structure. But by examining a knee-joint you may readily convince yourselves that this membrane is thicker and more succulent at most points than the pleura and peritoneum, and is separated from the fibrous capsule of the joint by a loose subserous cellular tissue, sometimes abounding in fat, so that you may readily detach, as an independent membrane, the synovial sac of a knee-joint as far as the cartilages. This membrane consists, as is well known, of connective tissue, has on its surface a generally simple, pavement epithelium, and contains a considerable capillary network close to the surface. Hueter has made investigations with regard to the lymphatics of the synovial membrane, and he states that these membranes are destitute of such vessels, while the subsynovial tissue is said to be copiously supplied in this respect. This result is very surprising, but it has been confirmed by Tillmanns in the case of rabbits and dogs; in oxen, on the other hand,

he found extensive networks of lymphatics, both on the surface and in the deeper layers of the synovial membrane. The surface of the synovial membrane, especially at the sides of the joint, exhibits a number of villous processes; these have a somewhat well-formed, often very complicated, capillary network. The synovial membranes share with other serous membranes the peculiarity of secreting, when irritated, a considerable quantity of serum. At the same time the vessels become dilated and begin to grow tortuous towards the surface; the membrane then loses its smooth and shining appearance, and becomes at first cloudy, yellowish-red, subsequently more and more red, and velvety on the surface. In most cases of acute inflammation a more or less thick fibrous deposit, a so-called false membrane, forms on this surface, just as occurs in inflammation of the pleura and peritoneum.

Microscopical examination of the synovial membrane in this state shows that its entire tissue is very copiously infiltrated with cells, and that on the surface the accumulation of these structures is so considerable that the tissue here consists almost entirely of small round cells, the most superficial of which have the exact characteristics of pus-corpuscles; in the immediate neighbourhood of the much-dilated vessels the accumulation of cells is particularly abundant, a condition which is probably due to the fact that in acute synovitis many white blood-cells wander through the walls of the vessels into the tissue, and remain in the neighbourhood of the vessels; it also appears that in these morbid processes red blood-corpuscles pass out of the vessels in very considerable quantity. The false membranes are entirely composed of small round cells, which are kept together by a coagulated fibrous material, of whose origin from fibrinogenous and fibrinoplastic substance we have already spoken (p. 86). The connective tissue of the membrane has partially lost its striated character and has a gelatinous mucous consistence, so that it very much resembles the intercellular substance of the granulation-tissue. In the fluid in the joint which is gradually becoming cloudy and puruloid, there are at first a few pus-corpuscles, which afterwards increase in number until the fluid gradually assumes all the characters of pus. Still later on the entire surface of the synovial membrane becomes so highly vascular that even to the naked eye it looks like a spongy, slightly nodular, granulation surface.

The condition into which the synovial membrane thus passes

is, in its first stages, most analogous to acute catarrh of the mucous membranes. As long as there has been only superficial suppuration without softening of the tissue (without ulceration), the membrane may return to its normal condition; but if the irritation be so great that not only are false membranes formed (which may still undergo disintegration), but the tissue also of the synovial membrane becomes the seat of parenchymatous inflammation and even suppuration, formation of a cicatrix can then be the only result. We have already shown in the description of a typical case of suppuration of the knee-joint that pus may penetrate from the cavity of the joint into the subcutaneous cellular tissue; this undoubtedly occurs, and almost always at those spots where the anatomical conditions are favorable; yet peri-articular purulent infiltrations of the subcutaneous cellular tissue sometimes occur after penetrating wounds of the joints without being dependent upon the passage of pus. We meet with these cases both in acute and chronic suppurations of joints without always being able to demonstrate any direct communication with the cavity of the joint. In accordance with my views on the phlogistic action of pus, I think that this suppuration of cellular tissue must be explained by the absorption of the quickly-formed poisonous pus by the lymphatics of the synovial membrane and its conduction into the peri-articular cellular tissue; this is always accompanied by swelling of the neighbouring lymphatic glands. We shall return to this when speaking of lymphangitis. It is only at a late period that the cartilage participates in the inflammatory process; its surface becomes cloudy, and, if the process be very acute, it begins to break up into fine molecules, or even to become necrosed in larger fragments, and partially detached from the bones by the setting-in of inflammation and suppuration between them and the cartilages (subchondral ostitis). Although the substance of the cartilage with its cells is morphologically not altogether inactive in these inflammations, still I consider that the participation of the cartilage in acute panarthritis is, in essential particulars, principally a passive process of softening, a kind of maceration such as occurs under similar circumstances in the cornea when there is severe blenorrhœa and diphtheria of the conjunctiva. There are, indeed, scarcely any other two parts of the human body which in pathological respects are so similarly analogous, as the conjunctiva in its relations to the cornea and the synovial membrane in its relations to the cartilage.

We shall frequently have occasion to return to this point, and will now leave these pathologico-anatomical studies with which we must occupy ourselves still more particularly hereafter. If the acute process subsides into a chronic stage and a stiff joint at last results, an anchylosis (from ἀγκύλη, a bending, because, as a rule, the joint becomes stiff in a bent position), it always occurs in the same way in all suppurative inflammations of joints. We shall go more minutely into this subject when treating of chronic articular inflammations.

LECTURE XVIII.

Simple Dislocations—Traumatic, Congenital, Pathological Luxations. Subluxations — Etiology — Difficulties in Reduction. Treatment. Reduction. After-treatment—Habitual Luxations —Old Luxations. Treatment—Complicated Luxations—Congenital Luxations.

Simple Dislocations.

By a dislocation (luxatio) we understand that condition of a joint, in which the two articular ends are either completely or almost entirely displaced and no longer occupy their relative position, the articular capsule being generally lacerated at the same time; this at least is almost always the case in traumatic luxations, that is, in those which have occurred in a healthy joint in consequence of the application of force. Besides these there is a class of dislocations called congenital, and another termed spontaneous or pathological. The latter result from gradual ulcerative destruction of the articular ends of the bones and ligaments, since the former no longer oppose sufficient resistance to muscular contraction; we shall speak of this later on, as it essentially belongs to the results of certain diseases of the joints. At the end of this section we shall make a few remarks with regard to congenital luxations.

At present we shall only describe traumatic luxations. You will also hear the term subluxation, which is applied to cases in which the articular surfaces are not completely but only partially separated, so that the luxation is incomplete. By complicated luxations we understand those which are accompanied either by fractures of bone or wounds of the skin, or laceration of large vessels and nerves. You must also notice that by general consent we designate the lower part of the limb as the part luxated, so that, for example, at the shoulder-joint, we do not speak of a luxation of the scapula,

but of the humerus; at the knee-joint, not of dislocation of the femur, but of the tibia, &c.

Luxations, generally speaking, are rare injuries; in some joints they are so uncommon that the whole number of cases known scarcely, perhaps, reaches half a dozen; it is asserted that fractures are eight times more frequent than dislocations, but it seems to me that even this is almost too great a proportion for the latter injuries. The distribution of luxations among the different joints varies very greatly; I will make this clear to you by a few figures. According to Malgaigne's statistics, among 489 luxations there were 8 of the trunk, 62 of the lower, 419 of the upper extremity; and among the latter, 321 occurred in the shoulder-joint. You will see from this that the shoulder-joint is the one which is peculiarly liable to dislocation; this is clearly due to its frequent use and great mobility. Dislocations are more frequent in men than in women, for the same reasons that we have already adduced for the greater frequency of fractures in men.

Dislocations may be caused by injuries and simple muscular action; cases of the latter kind are rare, but are sometimes observed where dislocations have been caused by spasmodic muscular contraction, as, for example, in epileptics. As in fractures, the external causes are divided into direct and indirect. For instance, if a man falls on his shoulder and causes a dislocation, we say that this is produced by direct force; the same dislocation might occur by indirect force, as, for example, when a person falls upon his hand and elbow-joint, the arm at the time being outstretched. Whether in one case a dislocation, or in another a fracture, will result depends principally upon the position of the joint and the direction and force of the blow; but much also depends upon whether the bones or the ligaments give way more readily; for by practising the same manœuvre on dead bodies of men of various ages, we may cause sometimes a fracture, sometimes a dislocation. As in fractures, there are many symptoms of dislocation having taken place, some of which may be very evident, and the more so the sooner the case is seen after the injury, and the less the dislocation of the joint is concealed by the inflammatory swelling of the soft parts above it. The altered form of the joint is one of the most important and striking symptoms, but it leads to a rapid and certain diagnosis only when the eye has been accustomed readily to recognise deviations from the normal form. A correct measurement

with the eye, accurate knowledge of the normal form—in short, some taste for sculpture and sculptural anatomy, so-called artistic anatomy—are for this purpose extremely useful. If there are extremely slight deviations from the normal form, even the most expert will not be able to dispense with a comparison with the healthy side, and I must therefore most strongly urge you, if you wish to make no mistakes in this matter, always to expose the upper or lower half of the body, according to circumstances, and to compare the two sides with each other. The best plan is to follow with the eye the direction of the supposed dislocated bone, and if this line does not strike the articular cavity exactly, you may then, in most cases, venture to assume that it is a dislocation; it might certainly be a fracture close below the articular head of the bone, but this must be determined by manual examination. The lengthening or shortening of a limb, its position with regard to the trunk, the separation from each other of certain prominent parts of the skeleton, often help us in rapidly diagnosing a luxation, at least with probability. Another symptom visible to the eye is bloody ecchymosis of the soft parts—sugillation. This certainly is seldom distinct at first, because the blood escaping from the lacerated capsule of the joint only gradually, perhaps not for several days, penetrates under the skin and becomes visible; in many cases the effusion of blood is so slight as not to be noticed. The symptoms which the patient complains of are pain and inability to move the limb in the normal manner. The pain is never so great as in fractures, and is only prominently manifest on attempting to move the limb. In some cases, patients with luxations are able to perform certain movements with the dislocated limb; but these are only possible in certain directions and to a limited extent. Manual examination must finally, in most cases, decide the question; by its means we must prove that the cavity of the joint is empty, and that the head of the bone is at some other point at one side, below, or above, as the case may be. When the soft parts are already very much swollen this examination may be extremely difficult, and it is frequently necessary to put the patient under chloroform in order to make a proper examination, which it would be difficult to do without this assistance on account of the manifestations of pain and movements of the patient. On moving the dislocated extremity, which we find springy or slightly movable, we sometimes perceive a feeling of friction, an indistinct, soft crepitation. This

may be caused partly by friction of the head of the bone against the lacerated capsular ligaments and tendons, partly by pressure of firm coagula. Hence, in such kinds of crepitation, we should not at once rush to the conclusion that we have a fracture to deal with, but we ought to examine the case still more minutely. Fractures of certain parts of the articular ends with dislocation are most readily mistaken for luxation. The mode of expression, especially in former times, was not quite correct on this point, inasmuch as displacements about joints, which were combined with fractures and due only to these, were also designated luxations. Now, we draw a sharp line of distinction between these fractures within the joint with dislocation and luxations proper.

Should you be in doubt as to whether you are dealing with a dislocated articular fracture or a luxation, you may easily decide the question by making attempts at reduction. If such a dislocation may be easily reduced with moderate traction, but at once returns to its former state when you let it alone, it is certain that you have a fracture to deal with; for, on the one hand, a very distinct and skilfully conducted manipulation is usually necessary for the reduction of dislocations; on the other, these latter injuries when once reduced do not, as a rule, so readily recur, although there are some exceptions to this statement.

Contusion and sprain of the joint may also be mistaken for dislocation, but this error may be avoided by very careful examination. Old traumatic luxations may sometimes be mistaken for dislocations, the result of contractions. Lastly, in paralysed limbs in which at the same time the capsules of the joints become relaxed, the joints themselves may become so excessively movable that in certain positions they look as if dislocated. The history of the case and careful local examination will in these instances also enable us to arrive at a proper conclusion.

As regards the condition of the injured parts immediately after the injury, in those cases in which there has been an opportunity for examination, the capsule of the joint and the synovial sac have both been found lacerated. The rent in the capsule is of very variable size, sometimes a slit like a button-hole, sometimes triangular, with more or less ragged edges; the muscles and tendons in the immediate neighbourhood of the joint are also sometimes found ruptured. The contusion of the parts varies greatly, as does also the degree to which blood is effused. The head of the bone does not always

remain at the spot to which it has slipped after passing through the rent in the capsule; but in many cases its position is higher, lower, or to one side, since the muscles which are attached to it cause it to become displaced by their contraction. It is very important to know that it is often necessary to bring the dislocated head of the bone into another position before we can succeed in carrying it back through the torn capsule into the articular cavity.

It occasionally happens that the injured person himself reduces the dislocation by some accidental muscular action. In the shoulder especially this has been more than once observed. Such spontaneous reductions are, however, very rare, because there are usually certain obstacles in the way which have to be overcome in skilful reduction. These obstacles consist partly in contraction of the muscles, between two of which the head of the bone may thus easily be caught. Another far more frequent obstacle is a small opening in the capsule, or its occlusion by the soft parts which have become forced into it. Lastly, in recent traumatic dislocations the capsular or accessory ligaments may be so stretched as to hinder the reduction.

The treatment of a dislocation consists in the first place in its skilful reduction, which must be followed by the adoption of means calculated to restore the function of the injured limb. We shall here only speak of the reduction of dislocations of recent origin, by which we understand those that have existed for, at most, eight days. The most favorable time for reducing a dislocation is immediately after the injury; we have then the least amount of swelling of the soft parts, and little or no displacement of the luxated head of the bone from its new position; the patient is still mentally and physically relaxed from the effect of the accident, so that the reduction not unfrequently is exceedingly easy. Later on we shall almost always require chloroform to facilitate the reduction, this remedy enabling us to get rid of the resistance offered by the muscles. As regards the proper manipulations for the reduction, there is but little to be said in a general way, for these, of course, are entirely dependent upon the mechanism of the different joints. Formerly there was a sort of general rule for the reduction of luxations; the limb was to be brought into the position in which it was at the moment of dislocation, so that by traction the head of the bone might be replaced in the same way as it had escaped. This rule is completely available only for a few cases; at present for the different

luxations we use in preference movements of very various kinds, such as flexion, hyper-extension, adduction, abduction, elevation, &c. Generally speaking, the surgeon in charge of the case directs these movements to be made by the assistants, and uses his own hand to push the head of the bone into its cavity when it has been brought near enough by the proper movements.

It often happens that the surgeon alone is able to reduce the dislocation; I myself have reduced several dislocated thighs at which various colleagues had worked in vain for hours with the assistance of powerful labourers. In these cases, everything depends upon a correct appreciation of the anatomical conditions, upon practice in picturing to our imagination anatomical forms. You will understand that, in a certain direction, often only slight force is required to cause the head of the bone to slip into its place, while it is quite impossible to do this in another direction. When the head of the bone enters the cavity of the joint, it occasionally causes a perceptible noise or snap, but this is not always the case, and restoration of the normal mobility is the only complete proof that reduction has been accomplished.

If we do not succeed with one or more manual efforts, we may employ several persons, and apply a loop with a long roller-towel to the limb and cause traction to be made in a definite direction. This traction, which must be opposed by counter-extension at the trunk, must be made uniformly and not in jerks. If even these means are not successful, we must have recourse to instruments to increase our power. Of these there are several kinds which were formerly employed—levers, screws, ladders, &c. At the present day the multiplying pulleys, or the Schneider-Menel extension apparatus, are almost exclusively employed. The pulleys, an instrument for increasing force, with which you are already familiar from your studies in physics, and which is constantly employed in mechanics, are used in this way:—one end is fixed to the wall by a strong hook, while the other is applied to the limb by straps and buckles. Counter-extension is then made on the body of the patient to prevent him from being dragged away by the action of the pulleys. An assistant draws the cord of the pulleys, the power of which, of course, progressively increases with the number of rollers employed. Schneider-Menel's apparatus consists of a large strong gallows, to the inner side of one post of which is attached a windlass which may be fixed at any elevation, and is turned by a handle and checked by a toothed wheel;

over this windlass runs a broad strap which is attached by a hook to the bandage applied to the dislocated extremity. In luxations of the lower extremity the patient lies upon a table, placed lengthwise between the posts of the gallows, or for reduction of a dislocated arm he sits upon a chair placed in the same way; counter-extension is effected by means of straps which fasten the patient to the post opposite the windlass. Both these apparatus have certain advantages, but their application is troublesome. You will have little to do with with them in your practice, as they are almost exclusively employed for old-standing luxations, the treatment of which is less frequently undertaken in private practice than in the surgical wards of hospitals.

At present, when we undertake forcible reductions of this kind, the patient is always first placed under the influence of anæsthetics. The anæsthesia must be extremely profound in order to produce complete relaxation of the muscles, and inasmuch as the chest is often covered with straps and belts for counter-extension, the greatest care is necessary, with regard to the quantity of the chloroform administered, in order to avoid dangerous symptoms of asphyxia. But besides these, there are also other dangers which were known to the older surgeons who did not use chloroform. These are as follows: the patient, if subjected for too long a time to these forcible manipulations, may suddenly become collapsed, and die; moreover, the limb may become gangrenous from the pressure of the straps around it; or there may be subcutaneous laceration of large nerves and vessels, and consequent paralysis, traumatic aneurisms, extensive suppurations, and other serious local accidents. As regards the consequences of pressure from the bandages, these may be best avoided by applying a damp roller to the limb from below upwards, and then fastening the straps over this. Inasmuch as a somewhat strong, uniformly distributed pressure is thus applied to the whole limb, the pressure of the straps close above the joints does not prove so injurious. As regards the time during which such forcible attempts at reduction should be continued, half-an-hour is certainly to be regarded as the maximum; for if after this time has elapsed we are still unsuccessful, we may be pretty well sure that the plan will not answer; and if we wish to make further attempts, we must try some other method. As to the amount of power which may be used without absolute danger we have no proper standard to guide us, and must, therefore, be satisfied with

using our own judgment. It seems scarcely possible by the above mechanical means to tear out an arm or a leg, and yet this has frequently occurred, not long ago, indeed, in Paris, in a case in which only manual extension was employed. Before this could happen the straps generally give way, or the buckles bend. Subcutaneous ruptures of nerves and vessels could scarcely be caused on a perfectly healthy arm by making uniform traction on the whole extremity; but these structures may be torn when adherent to deep cicatrices, and so much atrophied as to have lost their normal elasticity. If in such cases we could always form an accurate judgment beforehand as to the conditions, we should certainly in many cases wholly abstain from efforts at reduction; for the attempt to reduce the dislocation with the hands alone is just as likely to produce a rupture of a nerve or vessel, and the cause of such an accident cannot, therefore, be so definitely referred to the use of the machinery. There is an instrument by which the force employed in the extension can be measured; this is inserted into the extension apparatus, and indicates the force employed in measures of weight, as is customary in physics. According to Malgaigne, we should not go beyond 200 kilogrammes (440 pounds avoirdupois) with this dynamometer; but such statements are, of course, always only approximative.

When reduction has been accomplished by any of these methods the main point has certainly been gained, but some time is still required for the limb to regain its perfect functions. The wound in the capsule must heal, and for this purpose the joint must be kept completely at rest for a longer or shorter time. After reduction there is always a moderate amount of inflammation of the synovial membrane, with slight effusion of fluid into the joint, which for some time feels painful, stiff, and awkward. If reduction has taken place soon after the injury, as we are now supposing, the joint, in the first place, must be kept perfectly quiet; moist bandages are rolled round it, and cold compresses applied; the swelling is seldom so great as to require any other antiphlogistic remedies. In the case of the shoulder-joint we may begin to make passive movements after ten or fourteen days, and continue these until active movements and exercise can be prescribed; often many months elapse before the movements are quite free, the power of elevating the arm being that which is always the last to return. In other joints, which have somewhat less free mobility, active movements may be much earlier permitted; they are restored very much

earlier, for example, in the elbow- and hip-joints. In the latter joint, indeed, the patients may be allowed to move the limb much sooner, as luxations do not so readily recur here.

If active movements be permitted too soon after the reduction, particularly in those joints in which luxation readily recurs, as, for example, the shoulder and lower jaw, and dislocation again takes place once or more often before the torn capsule has perfectly healed, the result will be either that the capsule of the joint always remains partially open, or else the cicatrix will be so distensible that if the patient moves the limb at all carelessly, the bone will immediately again slip out of its place. We have then that condition which is called habitual luxation, very annoying and troublesome, particularly in the lower jaw. I knew a woman who had suffered from a dislocation of the jaw, and had not been careful of it for a sufficient length of time, so that it soon returned and had to be again reduced. The capsule was so enlarged that if, while eating, she took too large a morsel between the back-teeth, the jaw at once slipped out; she had so accustomed herself to the manœuvre of reducing it that she accomplished this with the greatest ease. In the same way habitual luxation may occur in the shoulder-joint. I have met in my practice with a young man who, when gesticulating violently, had to be especially careful to avoid raising his left arm too quickly, because this movement almost always produced dislocation of the shoulder. Such a state is very troublesome and very difficult to cure; recovery would be only possible by prolonged rest of the joint; but the patients seldom have inclination and perseverance for such treatment. Such patients ought to wear a bandage so adapted as to prevent them from raising and throwing back the arm too much; if the luxation can be prevented for some years, it is then not so likely to recur.

If a simple luxation be not recognised and not reduced, or if, for various reasons, we are unsuccessful in our attempts for that purpose, a certain amount of mobility is nevertheless gradually obtained, and this may be considerably increased by regular use. According to the position of the head of the bone with reference to the adjacent bony processes, and according to the displacement of the muscles, it may be readily understood that, for purely mechanical reasons, certain movements will be impossible; others, however, may be performed with almost the normal amount of mobility. If the movements do not become methodically restored, the limb remains

stiff, the muscles atrophy, and the extremity is of little use. The anatomical changes which the joint and the parts around undergo are as follows:—The extravasated blood becomes absorbed; the capsule becomes wrinkled and atrophied; the head of the bone remains against some other bone near the socket, against the ribs for instance, under the pectoralis major muscle, in dislocation of the shoulder-joint inwards; the soft parts around the dislocated head become infiltrated with plastic material, and converted into a cicatricial connective tissue which partly ossifies so that a kind of bony articular cavity again forms, while the head of the bone is surrounded by a newly formed capsule of connective tissue. The following changes, visible to the naked eye, take place in the cartilage of the head of the bone; it becomes rough and fibrous, and adheres, by a firm cicatricial connective tissue, to the parts on which it lies. As time goes on this adhesion becomes extremely firm, especially if not disturbed by movements. The metamorphosis of cartilage into connective tissue, followed out microscopically, takes place in this way: the substance of the cartilage breaks up directly into fine fibres, so that the tissue acquires first the appearance of fibrous cartilage, and afterwards of ordinary cicatricial connective tissue, which blends with the new parts around. In cases in which the new joint is diligently used, a very well-formed layer of cartilage may develope in the newly formed socket, and even the cartilaginous surface of the dislocated head may then be well preserved, and eventually be formed anew. This I found to be the case a short time ago in a post-mortem examination; in this case the deltoid muscle was yellowish in colour from fatty degeneration, the other muscles remained perfect.

In such conditions as these the luxations are said to be old-standing, and it is particularly for these that we make use of the above-mentioned forcible methods for reduction. The question, as to how long a luxation must have existed for its reduction to be pronounced impossible, cannot be answered definitely now that we have the assistance of chloroform, and the various joints would differ much in this respect. A dislocated shoulder, for instance, may be reduced after some years have elapsed, whereas it would be exceedingly difficult to replace a dislocation of the hip of two or three months' standing. The principal obstacles to reduction are the firm adhesions which have formed round the head of the bone in its new position, and the loss of extensibility of the muscles due

to the waste of their contractile substance, and their degeneration into connective tissue. Another question still remains—whether in these old luxations, even if reduction is successfully accomplished, the function of the joint will also be restored; this is especially important in the shoulder-joint. Supposing that the small socket of the joint is completely filled up and covered over with the atrophied capsule, and the head of the bone has lost its cartilage, even if we succeed in replacing the bone in its natural position, restoration of function is nevertheless impossible, and from my own experience, I can assure you that the final result of a very troublesome and tedious after-treatment in such cases corresponds in no degree to the expenditure of trouble and perseverance on the part of the patient and surgeon. The result in these cases will be scarcely more favorable than if the patient endeavours to increase the usefulness of the limb by methodical movements in its abnormal position, which it may have occupied for months or years. Such movements may be facilitated and assisted by placing the patient under chloroform, and breaking up the adhesions round the head of the bone by forcible movements of rotation. If the head, as happens sometimes in rare cases at the shoulder-joint, in its abnormal position, so presses upon the brachial plexus as to cause paralysis of the arm, we may, supposing that reduction is impossible, treat this by making an incision down to the head of the bone, dissect this out, and saw it off, that is, perform resection proper of the head of the humerus. I have seen a case of complete paralysis of the arm following dislocation of the humerus downwards and inwards; the above-mentioned operation produced considerable improvement of the function of the limb, though not a complete cure of the paralysis.

Complicated Dislocations.

A dislocation may be complicated in various ways; most frequently with fractures of separate portions, or of the entire head of the bone. In such cases, which are very difficult to diagnosticate, and in which replacement is often only partial and incomplete, the treatment must always be carried out with reference to the fracture, that is, the dressings must be continued until the fracture has united. It is at the same time desirable to renew the dressings more frequently, perhaps every eight days, and to apply them each

time in a different place, so that the joint may not become stiff. We do not, however, always succeed in obtaining complete mobility, so that I can only recommend you in practice always to let your prognosis be doubtful as to restoration of mobility in such cases.

Another complication is a simultaneous wound of the joint. It may happen, for instance, that the broad articular extremity of the lower epiphysis of the humerus, or of the radius, is so violently forced out of the joint as to tear through the soft parts and skin, and become exposed to view.

The diagnosis is, of course, in such cases easy; replacement is effected according to the rules given above, but we have still to deal with a wound of the joint of considerable extent. There are now all those possibilities of which we have spoken when treating of wounds of joints, so that with regard to the prognosis, the varieties of possible terminations, and the treatment, I may refer you to what has been already said (p. 305). The worst cases are, of course, those in which there are open fractures of joints; here we can expect neither a rapid healing up of the wound of the joint, nor a restoration of the function, and all those dangers have to be met which menace us in complicated open fractures and wounds of joints. It is easy to decide what must be done in such cases, whenever there is at the same time a considerable contusion or laceration of the soft parts; under such circumstances primary amputation must be performed. If the soft parts are not much injured, we may sometimes hope for a possible cure by suppuration, with a certainly stiff joint as a result. Experience, however, teaches us that this is always a somewhat dangerous experiment. In accordance with the principles of modern surgery, we may in such cases avoid amputation by dissecting out and sawing off the broken articular ends, and in this way converting the wound into a simple one. This is proper total resection of a joint, an operation which in the course of the last few decades has yielded very favorable results, and of which we moderns are justly proud; we have been thereby enabled in many cases to preserve limbs which, according to the maxims of the older surgeons, we should have been compelled to amputate.

The danger of these resections varies very greatly according to the joints on which they are performed, so that it is difficult to make any general statements in this respect. In a subsequent

section, however, (in the treatment of chronic fungous and granulous diseases of joints), we shall go somewhat minutely into this very important subject: what has been said will suffice to give you, for the present, some idea of a resection of a joint.

Congenital Dislocations.

Congenital dislocations are rare deformities, and must be carefully distinguished from *luxationes inter partum acquisitæ,* i. e. those which may be caused during birth by certain manipulations for delivery, and which are really simple traumatic luxations, and may be reduced and cured. Although we have on record cases of congenital luxations of the majority of the joints of the extremities, they are nevertheless particularly prone to occur in the hip-joint, and are frequently found on both sides at the same time. The head of the bone is placed somewhat above and behind the acetabulum, but in many cases it may easily be replaced. The deformity is, as a rule, first noticed when the child begins to walk. The principal striking feature is the peculiar waddling gait which is caused by the position of the head of the bone behind the acetabulum, so that the pelvis inclines more forward; in addition to this, the head of the femur in movements of walking often moves up and down; pain is always absent. In order to examine the child minutely, let it be quite stripped, and carefully observe its gait; then place it on its back in a horizontal position, and compare the length and position of the two extremities. In dislocation of only one side, the limb will be shorter than the other, and the foot somewhat turned inwards; the pelvis being fixed, you will, in many cases, be able to reduce the dislocation by simply drawing the limb downwards. The anatomical examination of such joints has yielded the following results:—Not only is the head of the bone dislocated from the socket, but the socket itself is irregularly formed, and too shallow; at a later period, in adults, it is greatly compressed and full of fat; the ligamentum teres, if present, is abnormally long; the head of the bone is not properly developed; in many cases it is scarcely half the normal size; the cartilage is usually perfectly formed, the capsule very large and relaxed.

Under these circumstances you can imagine that it is exceedingly uncertain, in most cases impossible, that a cure can be effected.

If the head of the bone is but slightly developed, the upper border of the acetabulum absent, the capsule enormously distended, how can the normal condition of things possibly be restored? Very various hypotheses have been advanced as to the origination of this peculiar malformation; up to the present time there has never been an opportunity of studying this disease in the embryo. It is an instance of arrested formation, the normal development having been interfered with in some way or other. It is assumed that these disturbances are the result of previous pathological processes in the fœtus; and of the many hypotheses the most reasonable is the one according to which, at a very early period of embryonic life, the joint became filled with an abnormal quantity of fluid, and thereby distended, so that, perhaps, a rupture or, at least, abnormal dilatation of the capsule was the result. Roser thinks that abnormal intra-uterine positions may be the cause of these malformations.

Attempts have been made to cure these cases, when, on direct examination, a fairly developed head of the bone has been found to exist. In such cases the dislocation has been reduced; and by means of dressings and bandages it has been attempted to preserve the normal position of the thigh, the child being kept in a position of absolute rest for a year or more. This treatment demands very great perseverance on the part of the surgeon and parents of the child, and the results, according to the experience of trustworthy surgeons, are only partially satisfactory, as such a course of treatment has scarcely ever been followed by improvement in the gait, certainly never by a perfect cure; and if it ever happens to you hereafter to read accounts in orthopædic pamphlets of numerous cures of congenital luxations, you may be quite sure that there have been errors of diagnosis in the majority of cases.

The congenital dislocations of the hip never become dangerous to life, but, inasmuch as they are accompanied by a change of the centre of gravity in the body, in the course of time they produce an effect upon the position and curvature of the vertebral column; this and a limping, waddling gait are the only inconveniences which result. The idea of any cure can be entertained only in very early youth; but as the surgeon can never promise a successful result, even from a course extending over one to three years, it is only rarely that patients are subjected to this treatment.

I will here allude to an extremely rare accident, of which only

one instance has at present come under my notice. The tendon of the long head of the biceps muscle of the arm may by certain movements be caused to slip out of its groove—the sulcus intertubercularis—and to remain against the large or small tubercle; the arm is thus fixed in a slightly abducted position. If the shoulder-blade be fixed, and the tendon relaxed by slowly raising up the arm, a slight rotation of the forearm easily causes the tendon to slip back into its groove; the pain immediately ceases, and all movements are restored. For this luxation to occur, the fascia-like membrane, which closes the groove and converts it into a canal, must, as a matter of course, either be torn or very much relaxed; the former is improbable; in great relaxation of the sheath the accident is prone to recur with certain movements. In some men the covering of the groove, in which the tendon of the tibialis posticus muscle lies, is so relaxed that they are able voluntarily to dislocate this tendon and also to effect its replacement, which is accompanied by an audible noise.

LECTURE XIX.

CHAPTER VIII.

GUNSHOT WOUNDS.

Historical remarks.—Injuries from large missiles.—Various forms of gunshot wounds from musket balls.—Transport and care of the wounded in the field.—Treatment.—Complicated gunshot fractures.

A GREAT number of injuries occur in war that are to be classed among simple incised, punctured, and contused wounds; gunshot wounds themselves must be classed among contused wounds; they present, however, so many peculiarities as to merit a special consideration, which will bring us into contact, though very briefly, with the proper domain of military surgery. Since firearms were first used in war (1338), gunshot wounds have been specially treated of by surgical writers, so that the literature on this subject has become very considerable; indeed, in recent times military surgery has been made almost an independent, separate branch, for it includes the treatment of soldiers in peace and war, the special hygienic and dietetic regulations which play a not unimportant part in barracks, in hospitals during peace and war, and in the clothing and feeding of troops. Although the Romans, as we have mentioned in the introduction, had surgeons previously appointed by the State with their armies, it was more the custom in the middle ages for commanding officers to take with them a private surgeon, who with one or more assistants attended, though in a very imperfect manner, to the soldiers after a battle, but then went on with the army, leaving the wounded to the care of compassionate people or of the monks, without the commander or the State assuming any responsibility about them. Only when

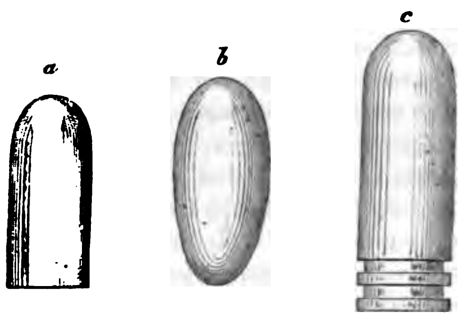
standing armies were established were surgeons assigned to certain battalions and companies, and regulations made, and accommodation provided, for the care of the wounded, though all this was still very imperfect. The position of military surgeons was at that time very ignoble, and such as would seem strange now, for even in the time of Frederick the Great, the army surgeon was publicly flogged if he permitted one of that monarch's tall grenadiers to die. At that time, when the troops in action marched at a parade step to meet the enemy, all the movements of the army were very tedious and slow; large armies were followed by immense trains; in the thirty years' war, for instance, the soldiers were frequently accompanied by their wives and children in an enormous number of wagons; hence in the medical arrangements belonging to the train there was no necessity for greater facilities of motion. The tactics which Frederick the Great introduced rendered necessary a greater mobility of the cumbrous trains, but it was only in the French army under Napoleon that this was systematically developed. As long as a very small portion of country, or a province, remained the seat of war during almost a whole campaign, the establishment of a few large hospitals in neighbouring cities might suffice. But when the armies moved rapidly after each other, and a battle was fought first in one place, then in another, the necessity arose of establishing easily movable, so-called "field-hospitals," not far distant from the field of battle, and which could be easily organised in one place or another. These ambulances, or flying field-hospitals, owe their origin to one of the greatest of surgeons, Larrey, of whom we have formerly spoken. As I shall by-and-bye briefly describe to you what is done with the wounded from the battle-field until they reach the principal field-hospitals, I will here pass from this subject, and mention to you only a few of the many excellent works on military surgery. Particularly interesting, not only in a medical but also in an historical point of view, are the certainly somewhat lengthy 'Memoirs' of Larrey, in which I particularly recommend you to read the campaigns in Egypt and Russia. These memoirs contain all Napoleon's campaigns. Another excellent work we possess in English literature, 'Principles of Military Surgery,' by John Hennen, and in German, besides many excellent works of older date; 'The Maxims of Military Medicine,' by Stromeyer, which is based principally on the experience of the Schleswig-Holstein war; finally, 'Principles of General Military Surgery

from Reminiscences of the Wars in the Crimea, and Caucasus, and from Hospital Practice,' by Pirogoff, and also in later times the writings on military surgery by v. Langenbeck, Beck, Esmarch, Löffler, Fischer, and others.

Wounds caused by large missiles, by cannon-balls, grenades, bombs, shrapnel, and other murderous weapons of whatever name, are sometimes of such a nature that they cause death at once; in other cases they tear off whole extremities, or at least so shatter them that the question can only be one of amputation. The extensive laceration and contusion which these missiles produce do not essentially differ from other large crushed wounds, which in the present time, in consequence of injuries caused by machinery, occur but too frequently in civil practice.

The musket balls, used in modern warfare, differ from each other in many respects. Occasionally we meet with the older forms of projectiles, quite round, oval, tapering, and partially hollow, but in the cartridge of the majority of modern breech-loading rifles

Fig. 64.



(*a.*) Chassepôt bullet. (*b.*) Bullet of Prussian needle-gun.
(*c.*) Mitrailleuse bullet. Natural size.

(Chassepôt, the needle-gun, the Werder rifle) the projectile has an elongated form, and is not hollow, but consists of solid lead. The Chassepôt bullet weighs 25 grammes, is 2½ centimètres long, cylindrical, has its apex rounded off, and is about 12 millimètres in diameter. The Prussian bullet weighs [illegible] grammes, is acorn-shaped, 2½ centimètres lo[illegible] ck. The projectile of the mit[illegible] Chassepôt, 4 cent[illegible]

mètres in diameter. You must not think that the projectile when found in the wound has the same form as in the cartridge; its shape is changed partly by the grooves of the gun, partly by the flattening caused by the bones, so that we very often find it in the wound a shapeless, broken-up mass of lead, from which the original form of the bullet can scarcely be recognised. We shall now briefly consider the various kinds of injuries which may be caused by a bullet, and in doing this we shall naturally confine ourselves to the principal forms.

In one set of cases the bullet causes no wound, but simply a contusion of the soft parts, accompanied by great sugillation and occasionally subcutaneous fracture. Simple subcutaneous fractures are not very uncommon in war; they are caused generally by spent bullets, *i.e.* such as come from a long distance and have not sufficient force to perforate the skin; such a bullet, striking the parts near the liver, may push the skin before it like a finger of a glove, and make a depression in, or rupture of, the liver, and then fall out without producing any external wound. Other such contusions are caused by bullets striking the surface of the skin very obliquely. Firm bodies, such as pocket-books, coins, pieces of leather on the uniform, may also prevent the entrance of the bullet. This kind of contused wounds, which, when they affect the abdomen or thorax, may be followed by very serious consequences, has always attracted the attention of surgeons and soldiers; such wounds were formerly generally supposed to be the so-called "grazing by the wind," and it was thought that they were caused by the bullet passing very close to the body. That injuries could really be caused in this way appeared so certain that even very sensible people worried themselves in attempting to explain theoretically how such injuries were produced by pressure of the wind: sometimes it was said that the air in front of and near the bullet was so compressed as to be able to exercise enormous pressure; sometimes the idea was that, from friction in the barrel of the gun, the bullet had possibly become charged with electricity, and could in some unknown way cause contusion and burning at a certain distance. If persons had been able to satisfy themselves earlier that the whole idea of grazing by the wind of a ball had no foundation in fact, these fantastic theories would not have arisen. Contusions from spent and obliquely-striking bullets are to be treated like contusions in general, according to the principles already laid down.

In the second case the bullet does not enter the soft parts deeply, but carries away a portion of the skin from the surface of the body, so that a more or less deep furrow remains, a so-called grazing. This is one of the slightest kinds of gunshot wounds, unless, as may happen on the head, the bone is at the same time superficially grazed by the bullet, and portions of lead remain in the skull.

In the third case the bullet perforates the skin and does not escape: it enters and generally remains in the soft parts, causing a tubular wound, a blind track. Into this various other foreign bodies may be carried, such as portions of uniform, pieces of cloth, buttons, pieces of leather, &c.; a bone may also be splintered and the splinters may be driven into the wound, and cause deep lacerations. It is also possible that the bullet, after perforating the skin and soft parts, may rebound from a bone and fall out of the same opening, so that it cannot be found in the wound, although there is only one aperture. The wound made by the bullet on entering the body is usually round, corresponding to the cross section of the bullet; its borders are contused, sometimes bluish-black and also somewhat inverted. These characteristics of the aperture of entrance are found in the majority of cases, but are certainly not absolute.

In the fourth and last case, the bullet enters at one point and escapes at another. We have then a perforating canal with an aperture of entrance and exit, a so-called "Haarseilschuss" (a seton shot-wound). If the track of the bullet has passed through the soft parts alone, and no foreign body been driven in, the aperture of exit is usually smaller than that of entrance, and more like a rent. If the bullet has struck the bones, and driven bone-splinters or other foreign bodies before it, the aperture of exit may be much larger than that of entrance, and there may be also two or more apertures of exit, caused by the division of the bullet into several pieces, and by several splinters of bone. In the last place, apertures due to escape of bone-splinters have been taken for the point of exit of the bullet, whereas this latter, or a portion of it, may be still in the wound. Far too much importance has been attached to the distinction between the apertures of exit and those of entrance. This distinction is important only in medico-legal cases, for in these it may be of great consequence to know from which side the bullet has come in a given position of the injured person, as the direction of the missile may give a clue to the author of the injury. The

course which the bullet takes in the deep parts is sometimes very peculiar. It is very often turned by bones or tense tendons and fasciæ, so that we should be greatly deceived were we to suppose that a straight line uniting the apertures of entrance and exit would always indicate the course of the bullet. Most extraordinary in this respect is the peripheral course sometimes taken round the skull and thorax; for instance, a bullet impinges upon the sternum obliquely, but without sufficient force to perforate this bone; the bullet may now run along a rib under the skin into the side of the thorax, or even to the spinal column before it escapes; from the position of the apertures of entrance and exit we might suppose that the bullet had passed obliquely on in a direct line through the chest, and be greatly astonished when such patients come from the field to have their wounds dressed, and do not exhibit any difficulty of breathing.

The complication of gunshot wounds with burns by powder, such as results from shooting at very close quarters, rarely occurs in war. In accidents from careless handling of fire-arms, or bursting of weapons, or in blasting, this combination is not rare, and may cause very various kinds of burns. The particles of charcoal in the powder often enter the surface of the skin with great force, and become healed over, so that for the rest of life the part retains a greyish-black discoloration. More with regard to this when speaking of burns.

In gunshot injuries there is said to be scarcely any pain: the speed with which the injury takes place is so great that the patient only feels a blow on the side from which the bullet comes, and only after a little time notices the bleeding wound and the peculiar pain. There are numerous examples of combatants having received a shot, especially in the upper extremities, and of being so little conscious of it, that their attention was first called to it by others, or by the blood flowing from the wound.

In gunshot, as in contused, wounds the bleeding is usually less than in those of the incised and punctured kind, but it would be a great mistake to suppose that the larger arteries when shot through do not bleed. On the contrary, many soldiers remain on the battle-field, having died from rapid hæmorrhage from the larger arterial trunks. Any one who has had an opportunity of seeing how a completely divided carotid, subclavian, or femoral artery bleeds, will be convinced that the loss of blood in a very short

time must be so great that the only hope of safety lies in immediate aid, and that hæmorrhage from these arteries lasting for about two minutes will certainly cause death. It is true, however, that arteries even as large as the femoral sometimes do not bleed at all when shot through. The first surgeons who gave us descriptions of gunshot wounds called attention to this circumstance.

Before passing to the proper treatment of gunshot wounds I will briefly describe to you the arrangements for transporting the wounded, and the first step for rendering them aid. For the latter purpose, certain places for dressing wounds are established in some sheltered place at a short distance behind the line of battle, usually in rear of the artillery; these places are marked out by the international signal of neutrality—a white flag with a red cross—and to these spots the wounded are first conveyed; the transport being undertaken by soldiers, or by specially trained medical orderlies or ambulance corps. The establishment of these ambulance corps has proved so beneficial in recent wars that they will be more extensively used; the corps are composed of nurses trained in a definite way to bring the wounded from the field, and, when necessary, to give them temporary aid; they are able, for instance, to compress arteries, and so arrest bleeding from wounds. They have been trained for two of them to carry a wounded man, either in their arms without other support, or in a quickly improvised litter. For this purpose they generally carry a lance and a large piece of cloth somewhat longer and broader than the body; the lances are passed through hems along the sides of the cloth, and in this way a stretcher is made; bayonets or swords may be provisionally used as splints to support a wounded limb. The wounded are thus brought to the dressing-place and the first dressings are applied; these are retained until the patient reaches the nearest field-hospital. At the dressing-place hæmorrhage must be securely arrested, wounded limbs so arranged that no injury may be caused by the transport; bullets lying superficially, foreign bodies, and splinters of bone which are quite loose, are here taken away, provided always that this can be done easily and rapidly. Limbs, completely shattered by large missiles, are here amputated if they cannot be so bandaged up as to admit of the patients being carried further. The particular object of this dressing-place is to make the wounded capable of bearing further transport, and it is therefore not proper here to undertake many and tedious operations.

From the great pressure of the constantly increasing number of wounded brought from the front, only what is absolutely necessary can be done here, and, cruel as it may appear, Pirogoff's advice is, nevertheless, very just when he tells us that the surgeons should not exhaust their strength by attending upon the mortally wounded and the dying. But, if possible, every wounded man when carried to the field-hospital should receive a short report of the results of the first examination; a card containing a few words, which is thrust, perhaps, into one of the pockets of the patient's dress, is sufficient. It is important to note whether the bullet has been extracted, whether a wound of the thorax or abdomen is a perforating one, &c., in this way saving the patient pain and the surgeon's time and trouble in the hospital. Hitherto, however, it has not been possible thoroughly to carry out such a regulation. Part of the ambulance corps is further charged with placing the wounded as comfortably as possible in wagons for further transportation, under the guidance of the surgeons. For this purpose there are special ambulances which may be constructed in very various ways, and in which patients may either sit or lie down. These wagons are certainly seldom sufficient, and recourse must often be had to common ones, adapted for the purpose as well as possible by means of planks, hay, straw, and mattresses. These wagons take the wounded to the nearest field-hospital, which is established in the nearest town or village, the best and largest attainable places being chosen; schoolhouses, churches, and barns are generally first seized, though only the latter are recommended. In these places beds are prepared with straw, a few mattresses, and bed-clothes; surgeons and nurses await anxiously the arrival of the first wagon with the wounded, having been made aware of the commencement of the battle by the thunder of the artillery and occasional reports. Here, now, begins the minute examination of those patients who were only provisionally attended to at the dressing-place, and operative activity is in full swing; amputations, resections, extractions of bullets, &c., are done wholesale, and the young surgeon, who has been anxious to perform his first operations on the living body, may go on operating all day till he stops from exhaustion. This continues till far into the night; the battle lasts till late in the evening, and it is towards morning before the last wagons bring the wounded to the field hospital. With bad lights, with an operating-table provisionally fitted up, often with unskilful

nurses as assistants, the surgeon must at once carefully examine, operate upon, and dress the wounds of every patient down to the last. In the field-hospitals the wounded have a period of rest, and, if possible, those who have been operated upon and are seriously injured should not be moved to another hospital until the healing has at least commenced. This cannot always be done; sometimes the place where the field-hospital was established has to be evacuated. If it becomes necessary for the conquered side to retreat, and the enemy then occupies the spot where the field-hospital was established, the surgeons remain with the wounded; for, even with the greatest humanity on the part of the enemy, the want of surgeons after great battles is often so great that the surgeons of the enemy are unable to take proper care of all the wounded. Some years ago in Geneva, a convention of European powers came to an arrangement by which surgeons and sanitary material of all kinds were declared neutral. Although there are obstacles of various kinds in practically carrying out this principle and its consequences, yet this convention has done a great deal of good in the wars of late years, and its arrangements are capable of still further development. At any rate, the principle of considering a wounded enemy as an enemy no longer, but as a patient, is to be prized and defended as an honourable characteristic of advancing humanity and culture.

When the wounded have all been temporarily brought under cover and placed in bed, and the necessary operations done, and all that is essential in other respects attended to, for example, the details of their feeding and treatment, the next duty of the medical staff is to take steps for their proper disposition. The accumulation of many wounded men in one place is injurious, and if the theatre of war is a poor country, with but scanty railway communication, the care of the wounded is attended with enormous difficulties. They must, therefore, be sent away as soon as possible; this may be done with good ambulances and with well-arranged hospital trains, even in the case of the badly wounded: when the means of transport are less convenient, the slightly wounded may at least be soon removed.

The system of scattering the wounded, which in recent times has been adopted with excellent results, requires great circumspection and much labour on the part of the superior medical and military authorities, but it has been proved to possess many advantages. If wooden houses (barracks) can be built for the

severely wounded who may remain behind, this will be the best plan; if this be not practicable, those who are slightly wounded, who require no particular surgical treatment, may be taken into private houses; it has been found undesirable to leave the wounded for long in churches and schoolhouses, for these buildings can seldom be well ventilated.

The war in North America, as well as that between Austria and Prussia in 1866, and the Franco-German war of 1870, have shown that improvements must constantly be made in military sanitary arrangements. One factor has been added, which was never before available, namely, the very great help on the part of societies, sisters of charity, civil surgeons, and many other persons, who devote either themselves or their money and materials, to the care of the wounded. When this private aid is properly organised, it may, under suitable guidance of the military authorities, be extremely useful, as has been proved in the last war.

With regard to the treatment of gunshot wounds, opinions have greatly changed in the course of time, according to the various points of view from which these wounds have been regarded. The oldest surgeons, whose opinions we possess, considered that gunshot wounds were poisoned, and thought, consequently, that they should be burnt out with the red-hot iron or boiling oil in order to destroy the poison of the gunpowder. The first to oppose this view successfully was Ambroise Paré, whom you already know as the introducer of the ligature. He relates, that in the campaign in Piedmont (1536) he had used up all the oil for burning the wounds, and that he then expected the death of all the patients who could not be treated according to the then existing rules of his art. This, however, did not happen; on the contrary, the latter patients did much better than the chosen few on whom he had used his supply of oil. Thus was surgery, by a lucky accident, very soon freed from this superstition. Subsequently, it was very correctly observed that the extreme narrowness of the track of the wound was one of the chief obstacles to the healing process in gunshot injuries, and attempts were made to obviate this by completely plugging the wound by charpie or gentian-root, both of them absorbent substances. But intelligent surgeons soon saw that this greatly prevented the escape of pus accumulated in the deep parts. By this time also the correct view that a gunshot wound is a tubular contused wound had gained some acceptance. This they again sought to improve

in a wonderful manner; a general rule was laid down that every superficial track of a wound should be completely laid open, the opening of a canal leading into the deeper parts was to be enlarged by one or more incisions; it was intended that, by means of these incisions, the contused wound should be changed into a simple incised wound, whereas, in fact, all that was done was to add an incised wound to the already existing gunshot wound. The case was somewhat different when the rule was laid down to cut out the whole canal of the wound, and to close the latter by sutures and compression in order to obtain healing by the first intention—a method which is seldom applicable and which has met with but little approbation. In recent times, when the treatment of all wounds has been so much simplified, that of gunshot wounds has participated in the improvement; these are treated upon the same general principles as contused wounds. The first thing which has to be done in a gunshot wound is, as in other wounds, to arrest any arterial bleeding. This must be done according to the rules already laid down—a ligature being applied to the bleeding artery either in the wound itself, or to the corresponding arterial trunk in its continuity; for the former purpose it is generally necessary to enlarge the opening of entrance or exit, for otherwise the bleeding artery could not be found. If there be no hæmorrhage, we should immediately examine the wound, especially the blind end of the track, for foreign bodies, particularly for any bullet that may be there. The finger is the safest instrument for this examination, but if not long enough or the canal too narrow to admit it, a silver catheter is the best substitute, with which we can feel more certainly and safely than with a probe. If the bullet is felt, we endeavour to remove it in the shortest way; that is, draw it out either at the aperture of entrance, or, if it has passed close under the skin, in a blind canal, we may make an incision through the skin, and extract it through this; thus, at the same time, changing the blind canal into a complete one. The extraction of the bullet from the aperture of entrance can be done with the aid of spoon- or forceps-shaped instruments. Bullet forceps with long thin blades are often difficult to use, because they cannot be sufficiently opened in the narrow canal to catch the bullet, and therefore many military surgeons prefer the spoon-shaped instruments for extraction. The American bullet-forceps is worthy of recommendation, its peculiarity being that it can be well opened even in the narrowest canals, and that it catches very securely; yet the

majority of such forceps are made too slight; I find that there is nothing better suited for the extraction of bullets than long, strong ear- or nose-forceps and polypus forceps. If the bullet is firmly fixed in a bone, we make use of a long gimlet, which is screwed into the lead, and in that way try to extract it; if we do not succeed in removing bullets or other foreign bodies through the aperture of entrance, we proceed to enlarge this so as to gain more room, and to be able to apply the instruments to better purpose. It has certainly been often observed that bullets have become healed over without exciting suppuration, but it is far more frequent for suppuration to ensue; as a matter of course no violent or dangerous manipulations should be made to extract bullets, but at the same time you must not be too much afraid of making diligent search for a projectile, if it keeps up prolonged suppuration. Hæmorrhage and difficulty of extraction of foreign bodies are the two primary indications for enlargement of gunshot wounds. Such enlargement, however, is by no means necessary for the healing of a wound. This takes place thus: from the aperture of entrance a small ring-shaped eschar is gradually thrown off, gangrenous shreds are then also detached from the track of the wound itself, until healthy granulation and suppuration set in, and the canal gradually closes from within outwards. In the majority of cases the aperture of exit cicatrises before that of entrance. It is true that there are many obstacles which may oppose this normal course; progressive suppurations may set in in the deep parts for which new incisions may be necessary, as in deep contused wounds in general.

The first dressing of a gunshot wound in the field consists usually in the application of a moist compress, covered with a piece of oil-cloth or parchment-paper, which is kept in its place by means of a bandage or cloth. It often happens that nothing further is subsequently required than simply keeping the wound moist, and covering it with some loose charpie, dressings with Goulard water, chlorine water, &c. The treatment of gunshot wounds without dressings was much adopted in the last war, and with results equally favorable as compared with the similar treatment of other wounds; in the next war we must try Lister's treatment. A gun-shot wound has been observed to heal by first intention, but this very rarely occurs; as a rule, all wounds of this kind suppurate for a shorter or longer period. One of the principal causes of deep inflammation is the presence of foreign bodies, such as bits of

accoutrements, leather, &c. The presence of a bullet, or of a portion thereof, is far less dangerous as regards healing. The cicatricial tissue may form around, and entirely encapsulate the lead; the wound closes perfectly over it, and the bullet remains in the patient's body. But these bullets, however, do not always remain in the same place; they sink, partly in consequence of their weight, and sometimes also are displaced by muscular action, so that in after years they are often found at another spot, generally one lower down. For instance, a bullet may enter the parts about the hip, and subsequently, being almost forgotten, may be felt under the skin of the calf or heel, and may here be readily excised. I have already told you about needles doing the same thing. Non-metallic substances, however, seem never able to remain thus in the human body without causing injury, and should therefore be always extracted when their presence in the wound is certain.

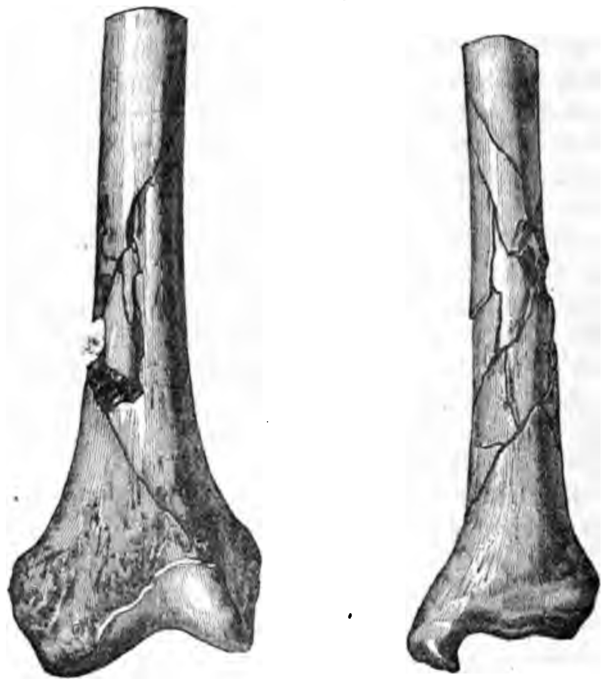
The fever in gunshot wounds will generally depend upon their size and extent, as also upon the accidental suppuration. In the excellently directed hospital of Surgeon-General Beck, of Baden, which I visited at Tauberbischofsheim, in the South-German seat of war (1866), the thermometer was used for determining the degree of fever, as also in 1870 in the Mannheim hospitals, which were under the superintendence of Professor Bergmann and Dr. Lossen. The results in general agree with those which have been obtained with regard to fever in other injuries.

In the treatises on special surgery, you will find the particular rules to be observed in perforating wounds of the skull, thorax, and abdomen; we shall here only make a few remarks on the fractures resulting from gunshot wounds. We have already observed that simple subcutaneous fractures occur also in war, from spent bullets and those which strike the parts obliquely; in most cases, however, the fractures are accompanied by wounds of the soft parts. The soft short bones and epiphyses, consisting of spongy substance, may be simply perforated by a bullet without any splintering of the bone necessarily occurring. This injury is comparatively favorable unless the neighbouring joint is opened by the bullet; this latter may remain in the bone and then keep up intense ostitis; bullets have been known to become healed up in bones, but such cases are always curiosities. After perforating wounds, suppuration occurs along the entire canal, which becomes filled up with granulations; these in part subsequently ossify, so that the firmness of the bone is

not impaired. If the bullet strikes the diaphysis of a long bone, it generally breaks it in splinters, and the wound is thus complicated in a very peculiar way; the great number of pointed splinters, as also the great amount of splintering in proportion to the diameter of the projectile, are enough to astonish those surgeons who are seeing for the first time a large number of gunshot wounds.

I consider it to be necessary and very important that every

Fig. 65.



Femur of a French soldier struck by a bullet from a German needle-gun.

Tibia of a German soldier struck by a Chassepôt (French) bullet.

gunshot fracture of the limbs shonld be carefully examined with the finger as soon as possible after the injury, so that the splinters of bone which are loose, or but slightly attached to the soft parts, may be removed; it may occasionally be proper to nip or saw off sharp ends of fragments, where this can be done without causing much fresh injury, without large incisions through thick soft parts. These so-called resections of bones in their continuity, I should not,

however, recommend for regular adoption, nor as always necessary, for experience teaches us that very many of such cases do well without operative interference.

If the injury has caused a complicated fracture in a joint, we cannot hope for much from an expectant treatment, according to present experience, which is based on statistics; on the other hand, the question generally is, whether it is better to perform primary resection or amputation; this can only be decided by the condition of each separate case.

Lastly, we must mention that secondary hæmorrhages are particularly common in gunshot wounds as in other contused wounds in general.

The treatment of gunshot fractures by means of fenestrated plaster-dressings is, in my opinion, a very proper one; it may, however, possibly be unsuitable in fractures of the upper part of the arm or thigh; on the other hand, it must be said that those surgeons who have not already treated open fractures with plaster-dressings, and who are not masters of the art of application, should not make their first attempts on gunshot fractures, but should apply only such dressings as they know how to manage. With regard to materials for splints for field-hospitals, we have not only to consider suitability and neatness, but should also select for the purpose such materials as are light and can be easily packed in the ambulances.

Secondary suppurative inflammations occur almost more frequently in gunshot than in other contused wounds; the same sources of mischief, which we have already found to be the causes of these dangerous accidental complications, are, unfortunately, equally prone to affect gunshot wounds.

LECTURE XX.

CHAPTER IX.

BURNS AND FROST-BITES.

1. *Burns: Grade, extent, treatment.—Sunstroke.—Stroke by lightning.* 2. *Frost-bites: Grade.—General freezing, treatment.—Chilblains.*

THE symptoms due to burns and frost-bites are certainly very much alike, but yet are sufficiently distinct to be considered separately. We shall, therefore, here first speak of

Burns.

These are caused by the action of fire itself, but more frequently by hot fluids, as, for example, when children pull down from the table vessels containing hot water, coffee, soup, &c., and pour the contents over themselves. Besides this, in factories burns from hot metals, from molten lead, iron, and the like are unfortunately not rare, and in everyday life slighter burns from matches and sealing-wax very often occur, and doubtless have happened to many of you. In addition to these, concentrated acids and caustic alkalies often produce burns of various degrees analogous to those caused by hot bodies.

In burns we have to consider the intensity and extent of the injury; we shall first study the intensity. This depends essentially upon the degree of the heat and the duration of its action; according to the results of this action burns are divided into different grades. These, it is true, run into each other, but they may with-

out difficulty be distinguished according to the accompanying symptoms; the object of this classification being to facilitate explanation. We assume three different degrees of burns:

First degree (hyperæmia). The skin is much reddened, very painful, and slightly swollen. These symptoms are due to dilatation of the capillaries with slight exudation of serum into the tissue of the cutis. There is a slight degree of inflammation accompanied by a reactive increase of cells in the rete Malpighii alone, and which is proved by the subsequent desquamation of the epidermis, at least in many cases. Redness and pain last occasionally only for a few hours; in other cases several days, but it is not necessary, and certainly not practical, on this account to further subdivide this degree.

Second degree (formation of vesicles). Besides the symptoms of the first degree, vesicles form on the surface of the skin; these, before they are broken, contain serum either quite clear or mixed with a little blood. These vesicles form either immediately or some hours after the burn, and may vary very much in size. On anatomical examination we find that in most of these cases the horny layer is detached from the mucous layer of the epidermis, so that the fluid which rapidly escapes from the capillaries is found between these two layers, just as results from the action of cantharides and vesicant-plaster. This vesicle breaks or is artificially opened; from the remaining rete Malpighii a new horny layer of the epidermis rapidly forms, and in six or eight days the skin is as it was before. It may, however, also happen that, after the removal of the vesicle, the denuded portion of skin is excessively painful, and superficial suppuration forms, lasting for several days or even a fortnight; the pus finally dries up into a scab, under which the new epidermis becomes formed. This state may also be artificially induced by allowing a blistering plaster to remain for some time upon one spot. It is, however, here also unnecessary to make new degrees of burns on account of these varieties, for they depend only upon a somewhat less or greater destruction of the rete Malphighii, just as the pain is more or less great according as the nerves in the papillæ of the surface of the skin are more or less exposed.

Third grade (formation of eschars). This degree includes in general all those cases where there is a formation of eschars; that is to say, those in which the burn produces mortification of a portion of the skin, and even of the deeper soft parts. Here, as a

matter of course, the varieties may be very great, for in one case there may perhaps be only burning and charring of the epidermis and points of the papillæ; in another, there may be death of a portion of the cutis; in a third, charring of the skin, or, indeed, of an entire limb. In all cases in which the papillary layer is destroyed with the rete Malpighii, there will be more or less extensive suppuration by which the mortified portion becomes detached; granulating wounds must then be formed as a matter of course, and these heal in the usual way. If only the epidermis and the surface of the papillæ be charred, the result is only slight suppuration, with rapid repair of the horny layer from the remains of the rete Malpighii.

From what has been said you will be able to understand that from four to seven, and even more, grades of burns may be formed, but it is quite sufficient for purposes of explanation to distinguish the three degrees—redness, formation of vesicles, and formation of eschar. In very extensive burns we often find these various degrees of intensity combined, and if the injured spot is covered with charred epidermis and dirt, it is often difficult at first properly to determine the degree at any spot. If suppuration occurs, it is sometimes superficial, sometimes deep; it sometimes appears as if islands of young cicatricial tissue formed in the middle of a granulating wound, and this has given rise to the false idea that the granulating wound may cicatrise not only from its borders, but also from single points in its midst. Such cicatricial islands, however, never form where the entire papillary structure of the skin is absent, but only from some remains of rete Malpighii left behind, as may happen in burns and certain ulcerations to be subsequently mentioned.

The prognosis with regard to the function of the burnt parts follows from what has been said. We must, however, add that after extensive loss of skin, as occurs especially from burns of the neck and upper extremities caused by hot fluids, there is very considerable contraction of the cicatrices, by which, for example, the head may be drawn quite to one side of the neck, or forwards over the sternum, or the arm become fixed in a flexed position by a cicatrix at the bend of the elbow. It is true that these cicatrices become, in the course of time, more extensible and yielding, but seldom to such an extent as completely to restore the function and remove the disfigurement, so that in many cases plastic operations

are necessary for these purposes. Strange to say, it was formerly asserted that cicatrices after burns contracted more strongly than other cicatrices. This difference, however, is only apparent, inasmuch as in other kinds of injuries there is scarcely ever so great loss of skin as takes place in burns; we can, moreover, easily satisfy ourselves, particularly in plastic operations and after great destruction of skin by ulcerative processes, that the contraction of the cicatrices is in these instances just as great.

As regards the danger to life, the extent of the burns is of the greatest importance, entirely apart from their intensity. It is generally assumed that if two-thirds of the surface of the body are involved in a burn of the first degree only, death will soon occur in a manner which has not as yet been physiologically explained. Persons thus injured fall into a state of collapse, with small pulse, abnormally low temperature and dyspnœa, and die in a few hours or days. In other cases life is somewhat more prolonged; death occurs sometimes from violent diarrhœa, in rare cases with the formation of ulcers in the duodenum close to the pylorus, a complication which also occasionally happens in septicæmia. Attempts have been made to explain in various ways the rapid occurrence of death in extensive burns: first, by supposing that the simultaneous irritation of almost all the peripheral endings of the nerves in the skin over-stimulated the central nervous system and caused paralysis; and, secondly, that the cutaneous perspiration was arrested by the burns, and death occurred in these cases just as in those animals whose whole body has been covered with an air-tight layer of oil-paint, caoutchouc, or resin. In the latter hypothesis it is assumed that the excretion by the skin of certain substances, especially of ammonia, is interfered with by the impermeable coating (as by the burning of the skin), and thus ensues a blood-poisoning fatal to the organism. Lastly, the symptoms might be the result of an intense phlogistic or septic intoxication, in the latter case where there is formation of eschar. Ponfick has lately again directed particular attention to the disturbance of the function of the kidneys; he found in the urine many of the so-called fibrinous casts from the uriniferous tubules. Should the extent of the burn not by itself cause death, in many cases the great loss of skin and the consequent suppuration may prove dangerous, especially to children and old people; in the same way, lastly, the amputations necessary in complete charring of single extremities involve a series

of dangers which are the more important, as they affect individuals already greatly enfeebled by the burn.

In the treatment of burns of the first and second degrees, it is more important to alleviate the subjective suffering of the patient than to adopt any energetic treatment; for we can in no way accelerate the return of the skin to its normal state, but must leave the course of healing entirely to nature. If there are any vesicles, it is not advisable to remove the loosened epidermis, but the vesicles should be opened by a few punctures with a needle, and the serum carefully pressed out, in order to diminish the feeling of tension caused by the vesicles. It would be most natural to cool the burnt portion of skin by applying cold compresses or plunging the parts in cold water; however, this is not much liked by patients, as the cold should be continuously applied and tolerably intense to cause much relief. The cold-water compresses become warm too quickly, and immersion in cold water is only applicable to the extremities; if they or the whole trunk were enveloped in cold applications every five minutes (for only thus could we get any effect from cold), this continuous disturbance would soon bring on a condition of great excitement and then a collapse; and hence it happens that cold is comparatively little used in burns. Many remedies are employed in burns which really only act by completely covering the inflamed skin: smearing over the surface with oil, and the application of wadding, is a very common and favorite remedy; as protective coverings, mashed potatoes, starch, and collodion are often applied to the burnt skin. The two former are to be regarded as popular remedies; for large burnt surfaces I cannot much recommend the collodion; the covering it forms cracks readily, and in these cracks the skin becomes sore and very sensitive. Many surgeons use particular ointments and liniments instead of oil; for example, a liniment composed of equal parts of linseed oil and lime-water, ointments of butter and wax in equal portions, lard, the rind of bacon, &c. Another plan of treatment is that with a solution of nitrate of silver (·5 gramme to 50 grammes of water, 4 grains to the ounce); this is painted over the burnt spots, compresses are laid on and kept constantly moist by frequent sprinkling with the above solution. At first the pain from the cauterisation by the nitrate of silver, of the parts denuded by epidermis, is sometimes very violent; but soon a thin, blackish-brown crust becomes formed, and the pain then entirely ceases. I particularly recom-

mend to you this treatment for those cases in which all three grades of burns are combined over a slight extent of surface. To many persons all moist and greasy applications are very unpleasant to the skin; we may then sprinkle over the reddened spots a powder composed of equal parts of starch and oxide of zinc, and cover this over with soft wadding.

The treatment of burns of the third degree differs in no way from that just described, in cases where only the cutis is burnt. This tissue when not charred, but only burnt by radiant heat or boiling water, generally becomes perfectly white. Should it be subsequently desirable to accelerate the detachment of the slough, and to diminish the offensive odour, we may use antiseptic dressings; the treatment by nitrate of silver can be continued until the eschar is completely detached. If very large granulating surfaces remain, especially on parts of the surface that are seldom at rest, and where the neighbouring skin is not very movable, it may require a very long time, often many months, for them to heal. Very luxuriant granulations form, and their tendency to cicatrise is always very slight. Of the remedies already mentioned for promoting the healing of such wounds, I particularly recommend to you the compression of the wound by strips of adhesive plaster, which acts admirably in many of these cases. Also in the treatment of these cicatricial contractions remaining after the burns, compression of the cicatricial bands with adhesive plaster is one of the most important remedies; and you will always do well to try this persistently, before you have recourse to excision of the cicatrix or to plastic operations.

If, in burns of a third degree, an entire limb has been burnt to a cinder, it will, in many cases, be advisable to amputate at once; not only because the detachment (by mortification) of large portions of the body is not free from danger, but also because the stumps thus formed are unfit for the application of an artificial limb.

If you are called to a case in which there is a burn of the greater part of the body, you must concentrate your attention upon the general condition of the patient, and try to prevent collapse by the employment of gentle stimulants, such as wine, warm drinks, warm baths, ether and ammonia. Unfortunately, in the majority of these cases, our efforts to preserve life are in vain. Hebra praises the treatment of extensive burns by continuous warm baths, which, with proper arrangements, may be kept up for weeks.

In persons of a delicate skin, and with prolonged exposure of

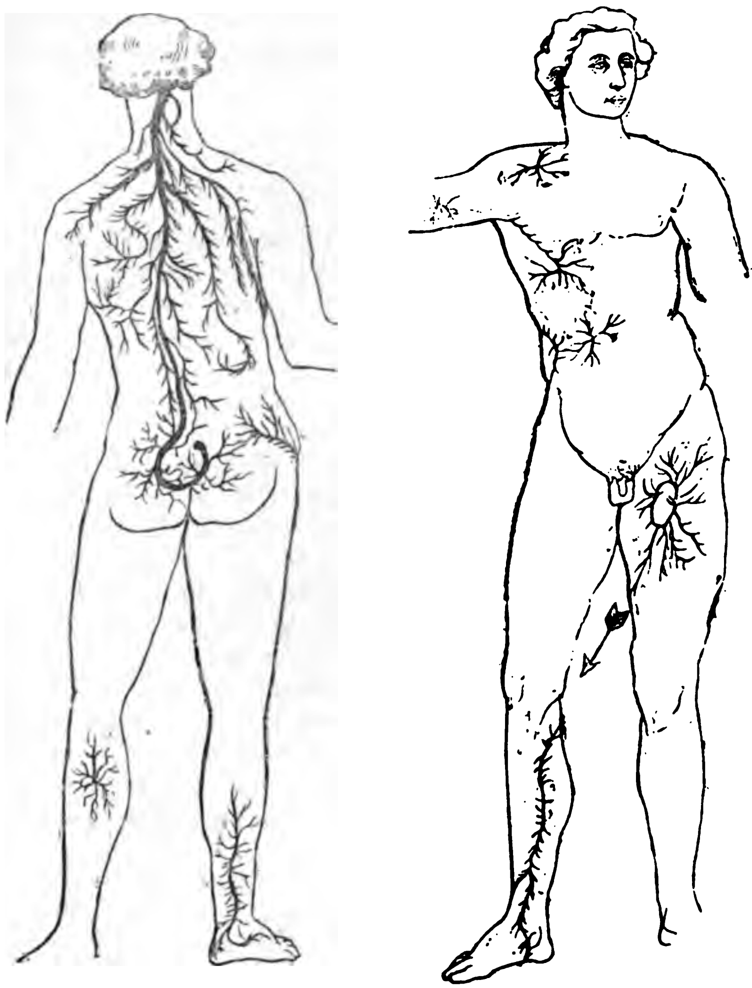
the face and neck, the sun's rays are able to cause burns of a slight degree. We often have an opportunity of seeing this in travellers in mountainous countries, where persons, ladies especially, who previously had never spent a whole day in the sunshine, travel for several days under a bright sky in summer without proper protection to the face and neck; the skin becomes red, swollen, and very painful; the epidermis dries up after three or four days into brownish crusts, becomes chapped and desquamates. In other individuals with a still more excitable skin, small vesicles also form which subsequently dry up without leaving any cicatrices (eczema solare). Besides the ordinary precautions in the shape of veils, sunshades, &c., it is well for such mountain travellers to smear the skin over with cold cream or glycerine; the same remedies are also used in pronounced sunburn; if the burnt parts are very painful, we apply cold compresses.

Here we must also allude to sun-stroke or heat-stroke. This disease occurs in our climate almost exclusively in young soldiers, when they have to make very fatiguing marches in full uniform in very hot and bright weather. The symptoms are violent headache, giddiness, unconsciousness, syncope, and sometimes death in a few hours. In the east, especially in India, this disease is not rare among English soldiers; some cases run quite an acute course and end with tetanic spasms; others begin with a longer premonitory stage, and continue with symptoms of violent headache, hot, burning skin, continued languor and depression, palpitation of the heart, twitching of the muscles, and when this state passes into recovery, relapses are very prone to occur. Patients with sunstroke are to be treated like those with great congestion of the brain. Cold affusions, and bladders of ice to the head, rest in a cool room, purgatives, leeches behind the ears, and sinapisms to the neck, are to be employed. Venesection is said to be injurious according to the experience of English surgeons.

We must here also make a few remarks as to the effect of lightning. You have probably all of you seen houses and trees which have been struck by lightning; there is usually a large rent, a cleft with charred edges. Also men and animals may be so struck as that single limbs are detached; but this is not always the case; the lightning generally runs along the body, in at one place, out at another, the clothes are torn, even completely torn off, and hurled

away; peculiar branched, brownish-red, zig-zag lines are found on the body, which have been regarded as the representation of the nearest trees, or as blood coagulated in the vessels and shining

Fig. 66.



Traces of lightning. After Stricker.

through; both these ideas being incorrect, for we do not know why the lightning takes this peculiar course on the skin. If a man be

directly struck by lightning, he is usually killed on the spot. If the lightning strike some spot quite close to him, then there are symptoms of concussion of the brain, of a greater or less degree, paralysis of separate limbs, or of organs of special sense; also here and there extravasations and burns. The latter heal, like other burns, according to their degree and extent; paralysis from lightning is not usually of bad prognosis, as the nervous or muscular functions may sooner or later be restored.

Frost-bites.

Frost-bites, like burns, may be divided into three grades, the first of which is characterised by redness of the skin, the second by the formation of vesicles, the third by that of eschars. The first degree of frost-bite is pretty well known; the slightest form is seen in the so-called deadness of the fingers, which probably every one of you has sometimes experienced in a cold bath or in cold wind. The fingers become white, the skin wrinkled, the sensation diminished; after a short time these symptoms pass off, the skin becomes red, the fingers swell, and there is a peculiar sensation of itching and pricking. This becomes greater the more quickly the cold is followed by warmth. The redness of the skin in this degree of frost-bite differs from that in burns by its more violet colour.

These symptoms after a time subside, and the skin again becomes normal. Usually no remedies are used for these slight degrees of frost-bite, but in general practice patients are cautioned against warming the parts too quickly; rubbing with snow is recommended, and subsequent gradual elevation of the temperature. The explanation of the above symptoms is that at first the cold produces great contraction of the capillaries, and that then they become paralysed for a long time.

Redness following a frost-bite may sometimes become permanent, that is, the capillaries remain permanently dilated. This is especially apt to occur in frost-bites of the nose and ears, and in many cases is almost incurable. In Berlin I treated a young man whose nose, after frost-bite, had retained its dark bluish-red colour, and who wished to be cured of this disfigurement at all hazards. He followed out with the greatest persistence all the various modes of treatment; at first he had his nose painted over with collodion, after

which it looked as though varnished, and, so long as the coating of collodion remained, was somewhat paler, but the improvement did not last. Then the nose was painted over with dilute nitric acid, which gave it a yellowish tint. After the epidermis had become detached, the disfigurement again appeared to be improved for a short time, but it soon returned to its former condition. Then we tried the application of tincture of iodine and nitrate of silver, which gave the nose a brownish-red, then a brownish-black colour for a time. All these changes of colour were submitted to by the man with heroic patience; but the refractory capillaries remained dilated, and the nose bluish-red, just as before. I still thought of trying the application of cold, but feared that the condition might possibly be made worse, and was compelled to inform the patient with this tragi-comical history, after several months' treatment, that I could not cure him. Just as great difficulties are to be met with in curing chilblains and their ulcers; of these affections we shall soon speak more particularly.

When a frost-bite is accompanied by vesicles as well as redness, it is much more severe; in such a case there is often complete loss of sensation in the affected part, and there is always imminent danger of complete mortification. The prognosis in frost-bites with formation of vesicles is much worse than in burns with the same symptoms. The serum contained in the vesicles is seldom clear, but generally bloody in colour, this being due to the colouring matter which the red blood-cells have imparted to the serum. Blood frozen and afterwards thawed remains red (lake-coloured, Rollet), but the blood-redness is always independent of the cells. A limb completely frozen is said to be perfectly stiff and brittle, and small portions are said to break off like glass, under rough handling. I have had no opportunity of testing this statement, but I remember, when I was a student, seeing a man in the Göttingen surgical clinic with both feet frozen, which, while he was being brought to hospital, had become spontaneously detached at the ankle-joint, so that they hung only by a few tendons; double amputation of the leg had to be performed above the malleoli. How far a limb is entirely frozen, so that the circulation therein is completely stopped, cannot often be positively determined for some time; in view of this one must not be too hasty in amputating. In Zurich I met with two cases where both feet were dark blue and had lost feeling, and where a deep prick with a needle was followed by the escape of only a drop of

black blood; nevertheless the foot recovered itself, and only a few toes were lost; subsequent experience, however, has taught me that such a result is rare. In a third case, in a very debilitated patient, both feet were of a dark bluish-red colour and covered with vesicles as high up as the calves, and became completely gangrenous. If extensive gangrene of the skin be undoubtedly present, we must not delay amputating, for these patients are very liable to pyæmia. A very sad case came under observation in the Zurich hospital; a young, powerful man had both hands and both feet frozen, so that all his limbs became gangrenous; the patient could not make up his mind to four amputations, and I could not bring myself to persuade him to this fearful operation; he died of pyæmia.

Besides the ends of the extremities, the tip of the nose and the ears are most liable to be frozen; closely fitting clothes which impede the circulation increase the predisposition to frost-bite. Cold winds, and cold accompanied by moisture, are more apt to induce frost-bite than higher degrees of cold with still, dry weather.

There is also a total freezing or stiffening of the whole body, in which the patient loses consciousness and falls into a state in which the signs of life are very slight indeed; the radial pulse cannot be felt, the heart's impulse is scarcely audible, the respiration scarcely perceptible, and the whole body icy cold. This condition may pass immediately into death, all the fluids of the body then become completely frozen. Such a general freezing is particularly apt to occur when individuals, tired out perhaps with long travelling and by the cold itself, lie down in the open air; they soon go to sleep, in many cases never more to awake. How long a person may remain in such a frozen condition, with all the signs of life at their lowest point, but recovery being possible, has not been exactly determined. It is said that this state has continued for six days; whether this be true or not, the attempts at resuscitation should at any rate be continued as long as any trace of the heart's impulse can be detected.

Let us begin the treatment of frost-bite with that of this state of general stiffness. I myself have no experience of this so-called asphyxia from cold, but I may say that, in accordance with universal opinion, every sudden change to a higher temperature should be avoided, and, on the other hand, the temperature must be increased very gradually. Such a patient should be brought into a cold chamber, placed in a cold bed, and have his body rubbed for several

hours. As slight stimulants, which are here indicated, I may mention enemata of cold water, and ammonia to the nostrils. When the patient has recovered consciousness, the surrounding temperature may then be very gradually increased; he may be kept for a time in a slightly warmed room, and only lukewarm drinks at first given. As the different parts of the body, one after the other, recover their vitality, there is generally a great deal of pain in the limbs, especially when the warming has been too rapid, and in these cases it is well to envelope the painful parts in cloths saturated with cold water. The patient may remain for hours and days in a somewhat benumbed, senseless condition, which only gradually passes off. Experiments have lately been made on the restoration of frozen animals, and these appear to show that restoration takes place more certainly by rapid than by slow warming; from these experiments upon animals I should not at once make up my mind to depart from the rules which have become empirically developed for the treatment of frozen persons, but the matter is worthy of further experiments. Such general frost-bite will seldom pass off without loss of separate limbs or parts thereof; and I have but little to add with reference to the treatment of these frozen parts. The vesicles are punctured and emptied; the feet and hands may be wrapped with cold wet cloths; we must then wait and see whether gangrene will set in, and how far it will extend. If the bluish-red colour gradually passes into a dark cherry-red, the chances of restoration of vitality are extremely slight; on the contrary, gangrene usually occurs in such cases. By testing the sensibility with a needle, and noting the escape of blood from these fine punctured openings, we endeavour to discover how far the limb is to be considered dead; but a positive decision is possible only when the line of demarcation forms, that is, when the dead part is sharply marked off from the living, and the rosy, inflammatory redness of the skin becomes developed on the borders of the gangrenous portions. The general condition, however, of the patient may become very perilous before the formation of this boundary line; we should therefore not hesitate too long about amputating, if the inflammation occurring after the freezing assumes a phlegmonous progressive character. The detachment of single toes and fingers may be well left to take its own course, but in gangrene of a larger portion of the hand or foot, amputation is decidedly preferable.

Samuel's recent experiments have shown that, after certain degrees

of frost-bite, a genuine inflammation ensues, which passes on into inflammatory mortification, true gangrene. Clinical observation has certainly taught me that a change here takes place, not found in simple burns, inasmuch as the burnt tissues, even if not charred, shrivel up and the blood coagulates in the vessels, so that, even if their connections are preserved, they are rendered impenetrable to the flow of the arterial blood. When a frozen limb is thawed, the arterial blood is then for some time again able to enter the vessels, and all will now depend upon whether the vascular walls are in a condition to receive the blood now fluid, and the tissues, to make use of the portion of blood sent to them. Where this is the case the frozen limb may recover; where it is not the case, gangrene results. During this transition stage the veins remain particularly dilated, a condition essentially conducive to stasis and thrombosis. Bergmann recommends especial attention to be paid to the treatment in this stage; he has obtained extraordinarily favorable results by suspending the limbs vertically, thus greatly facilitating the return of venous blood.

I will now, by way of supplement, return to chilblains (perniones), not because they may become particularly dangerous, but because they are small troubles, exceedingly annoying, and in many cases very difficult to cure, and for which you, as good general and family doctors, must have at command a series of remedies. Chilblains are caused by paralysis of the capillaries, with serous exudation into the tissue of the cutis; they are, as most of you know, bluish-red swellings on the hands and feet, and are exceedingly troublesome by reason of the violent burning and itching, and the occasional ulceration which ensues. They are caused by repeated slight frost-bite on one and the same spot, and do not occur with equal frequency in all persons; they are much less troublesome in very severe frosty weather than when a thaw is taking place. When the patients go to bed at night, and their extremities become warm, the itching sometimes becomes so dreadful that they are obliged to scratch their hands and feet for hours together. Generally speaking, women are more disposed to chilblains than men, young persons more than older ones. Employments which cause frequent change of temperature particularly predispose to them; shopmen and apothecaries, who are sometimes in warm rooms, sometimes in cold shops, very often suffer from chilblains. No station is, however, exempt; persons who always wear gloves, and seldom stir out in winter, are as prone to be attacked as those who have never worn gloves. In

women, chlorosis and menstrual disorders appear sometimes to predispose; the frequent recurrence of chilblains seems generally to be connected with some peculiarities of constitution.

As regards the treatment, it is usually extremely difficult to deal with those causes which are due to constitution and occupation; hence we are obliged to content ourselves principally with local remedies. In Italy, where chilblains occur pretty frequently whenever the winter is colder than usual, frictions with snow, and ice compresses are recommended. With us these are less used, and do no good, or at most only lessen the itching for a short time. An ointment with white precipitate (·5 grms. to 40 grms. of lard), friction with fresh lemon-juice, painting over with nitric acid diluted with cinnamon-water (5 grms. to 150 grms.), a solution of nitrate of silver in water (·5 grms. to 50 grms.), and tincture of cantharides, are remedies which you may employ one after another; sometimes one does good, sometimes another; hand- or foot-baths with hydrochloric acid (from 40 to 60 grms. to a foot-bath used for ten minutes), bathing with infusion of mustard seeds, are also celebrated remedies. If the chilblains become open upon the surface, they may be dressed with ointment of zinc or of nitrate of silver (·05 grm. to 5 grms. of lard). I have here mentioned to you only a small number of the remedies recommended, the effect of which I have for the most part myself tested, although there are many others; these named will, however, be enough for you at the commencement of your practice for dealing with this troublesome complaint.

LECTURE XXI.

CHAPTER X.

THE ACUTE NON-TRAUMATIC INFLAMMATIONS OF THE SOFT PARTS.

General etiology of acute inflammation.—Acute inflammation:—
1. Of the cutis: a, Erysipelatous inflammation; b, furuncle; c, carbuncle (anthrax, malignant pustule).—2. Of the mucous membranes.—3. Of the cellular tissue. Hot (acute) abscesses.—4. Of the muscles.—5. Of the serous membranes, sheaths of the tendons, and subcutaneous mucous bursæ.

Gentlemen,—Hitherto we have been exclusively occupied with the consideration of injuries; we shall now pass on to those acute inflammatory processes which are not of traumatic origin. Of these processes, those that occur on the external parts of the body belong to surgery, as well as those which although occurring in internal organs, are still accessible to surgical treatment. Although I must assume that you are already acquainted with the causes of disease in general, it nevertheless seems necessary to make some preliminary remarks on the subject of causation, with special reference to the diseases of which we are about to treat.

The causes of the acute non-traumatic inflammations may be divided into the following categories.

1. *Repeated mechanical or chemical irritation.*—At the first glance, this cause seems to be one of a traumatic kind; it makes, however, an essential difference whether such an irritant acts once upon the tissue, or whether it is rapidly repeated, for, in the latter case, each successive irritation affects a tissue already irritated. An example will make this clear to you. Suppose that a person has a sharp nail in his boot or shoe, and that this nail constantly rubs against the same part of his foot, the result at first would be a slight

wound with circumscribed inflammation, which, however, would spread, and at the same time become more intense, as long as the irritation lasted. Let us now take an example of repeated chemical irritation. If a person, unaccustomed to pungent food, takes some cayenne pepper, a slight transitory hyperæmia and swelling of the mucous membrane of the mouth and stomach are the results; if so pungent a substance were to be repeatedly taken for a length of time, it might induce severe gastritis. With the exception of the first-mentioned example, such rapidly repeated irritations do not very often occur in practice; they have, however, a great deal to do with the causation of chronic inflammatory processes, when, even if insignificant in themselves, they act upon more or less debilitated parts. We shall afterwards return to this point.

2. *Catching cold.*—All of you know that diseases of various kinds, especially acute catarrhs and inflammations of the joints or lungs, may be acquired by taking cold. But we do not know upon what the peculiar noxious influence in taking cold depends, or what changes are thereby immediately produced in the tissues. Rapid change of temperature is principally blamed as the essential cause of catching cold, yet if one tries it as an experiment, neither inflammation nor any other kind of disease, attributable to taking cold, can be produced. A person catches cold from being heated, and then being exposed for a long time afterwards to a cold draught of wind; this is a well-known fact, and by careful observation a person may be able sometimes to indicate the exact moment when the cold seized him. There are purely local effects of cold; for instance, a person sits for a long time at a window, and a cold draught of wind blows on the side of the face which is turned towards it; after a few hours he is attacked by paralysis of the facial nerve; we may assume that in this case molecular changes in the nerve-substance have taken place, by which the conducting power of the nerve is lost. Another person under similar circumstances is attacked by conjunctivitis, as a result of the cold draught. These are purely local colds. Another case is more frequently seen, namely, that after catching cold that part suffers which, in the individual affected, is in a general way most liable to disease—the *locus minoris resistentiæ.*

There are persons who, after catching cold in any way, suffer from acute catarrh of the nose (snuffles), others who from the same cause get catarrh of the stomach, others, again, muscular pains,

while others have inflammations of the joints. Inasmuch as these parts are by no means always directly affected by the cause of the mischief (as, for example, when any one gets his feet wet and nasal catarrh follows), we must certainly suppose that the body as a whole is concerned, and that the effect of the mischief makes itself felt only on the *locus minoris resistentiæ*. Whether the nerves, or the blood and other fluids of the body, are to be regarded as the channels and distributors of such injurious influences to a special part of the body, is a question which cannot at present be decided, and about which physicians are divided into the two great camps of Neuro-pathologists and Humoral pathologists. Reasons may be adduced for both views; I myself decidedly incline to the humoral theory, and consider it possible that, for example, when the skin is perspiring and suddenly exposed to the action of a draught, certain chemical changes may result, the products of which may be retained and gain admission into the blood, and may then act as a sort of poison upon this or that organ; of this we shall presently speak more in detail. According to the old form of speech those inflammations which are produced by catching cold, are called "rheumatic" (from ῥεῦμα, a flow); this expression is, however, so much misused and has come into such disrepute, that it is well not to use it too frequently.

3. *Toxic and miasmatic infection.*—We have stated in a previous page that moist and dry, purulent and putrid substances, brought into contact with a wound, excite violent progressive inflammation, if such substances enter the healthy tissue either immediately after the injury, or, under certain already mentioned conditions, pass through the granulations of a wound into the tissue. We have already alluded to the possibility of the very minute fungiform vegetations being the carriers and diffusers of the morbid material, but without assuming that the spread of the acute inflammations was due to such vegetable organisms alone. The surface of the body is pretty well protected by its epidermis, the mucous membranes by the mucous and thick epithelial layers, against the introduction of such injurious substances exciting inflammation and blood-poisoning, but the protection is by no means perfect. There are many poisonous substances which enter the body sometimes through the skin, sometimes through the mucous membranes. To some of these we give the direct name of poisons—for example, the secretion from glanderous ulcers in horses, or from the carbunculous pustules in cattle; others are known to us only by their effects or by some

conditions of their origin. There are invisible bodies, which we term "miasmatic poisons" or briefly "miasms" (μίασμα, impurity); it is supposed that these miasms become developed from decomposing organized bodies. Some consider them to be gases, others dust-like bodies, others, as above mentioned, think they are very minute organisms or their germs. The action of these poisons varies in so far as some of them have a direct phlogistic action, while of others the action is more indirect. Some poisons, as putrid pus and cadaveric poison, excite violent inflammation at the spot where they enter the body (*infectionsatrium*), others excite no inflammation at the place where they penetrate the organism, but are imperceptibly taken into the blood, and then set up inflammatory processes in one or more parts of the body though circulating with the blood through all the organs; these poisons are to a certain extent injurious only to certain organs, on these they have a "specific" action. I shall not here discuss the action of these poisons in causing changes in the blood. We have no knowledge of the chemically active constituents of the majority of these poisons which act specifically upon one organ or upon certain tissues; we cannot see them circulate, we cannot always see how their action is manifested; you are, therefore, quite justified in asking me how it is that the existence of these substances can be so positively asserted. The fact is, that we decide upon the causes by observing the morbid processes, and, in so doing, depend mainly on the analogies with other poisons intentionally introduced into the body, basing our theories especially upon the mode of action of our most powerful remedial agents. Let us take the group of the narcotics; they all have a benumbing action, evinced with more or less intensity and with more or less rapidity, that is, they paralyse the psychical functions, but they have in addition the most wonderful specific effects; thus, belladonna acts upon the pupil, digitalis upon the heart, opium upon the intestines, &c. We see the same thing in other remedies; by repeated doses of cantharides we may excite inflammation of the kidneys; by mercury, inflammation of the mucous membrane of the mouth and of the salivary glands; these effects being produced whether the medicines are introduced into the blood through the stomach, the rectum, or the skin. So there is also a countless number of known and unknown organic septic poisons, many of which, if not all, have specific inflammatory active properties. I mention only one example. If you inject putrid fluid into the blood of a dog, you will in many cases cause not only

the direct symptoms of blood-poisoning, but also enteritis, pleuritis, perhaps even pericarditis: must we not here suppose that the injected fluid contains one or possibly several substances which have a specific inflammatory action upon the mucous membrane of the bowels, the pleura, and pericardium? As long as we know the place of entrance of the poison, and have some experience of the poison itself, there will rarely be a doubt as to the cause and action. Yet how many cases are there in which neither the one nor the other is known! I believe that infection is a much more frequent source of inflammations in surgical, as well as in internal, diseases than we have hitherto been accustomed to suppose.

I would still make a few general remarks with regard to the *forms* and the *course* of the non-traumatic inflammations. I have already told you that the distinguishing character of traumatic inflammations is, that of themselves they always remain limited to the immediate neighbourhood of the wound; if they become progressive, it is generally from new mechanical or toxic (septic) irritation. This would signify that the primary inflammations, caused by repeated mechanical irritation or toxic action, have a tendency to progression, or at least to a diffused advance; this is also the case with the majority of inflammations resulting from catching cold, which attack either an entire organ or a large extent of a portion of the body. Hence, of course, in mechanical irritation it is the *intensity* that is of decisive importance; in the toxic inflammations it is the quality and quantity of the poison which has entered, especially its more or less fermenting action upon the fluids permeating the tissues. As regards inflammations due to repeated mechanical irritation and catching cold, we do not always have reason to assume that the products thereof have a more irritating effect than those of simple traumatic inflammation; if, however, in the latter case the affected part is kept absolutely at rest, and the lymphatics and interstices of the tissues are closed by infiltration in the parts about the wound, the extension of the inflammatory products into the surrounding parts is much impeded. But in repeated mechanical irritation, the tissue is not left at rest, and consequently the products of inflammation extend without hindrance into the parts surrounding the irritated spot, and here again excite inflammation. In inflammation produced by catching cold, according to my humoral theory, the *materia peccans* is poured perhaps into an entire organ, or a distinct portion of tissue, and therefore these

inflammations are generally diffuse from the commencement. We have as yet no clear knowledge with regard to the causes of the extension of acute inflammations; there is no doubt but that the anatomical relations of the tissues, the arrangement of their fibres, &c., play a part therein; but we have also to consider individual predispositions, and the conduct of the patients (for example, whether they go on working with an inflamed hand in spite of very severe pain). Possibly in all acute inflammations, a ferment-like body becomes developed in the inflammatory focus (a zymoid, from ζύμη, leaven, yeast), which, conveyed into the tissues, not only always excites new inflammation, but is always reproduced *de novo* in the new inflammatory foci. In the absence of these hypotheses, we should be forced to assume that the inflammatory matter which first produced the inflammation is so intensely poisonous that, when excessively diluted and concealed in the tissue, it always causes inflammation; for the acute inflammations, produced by mechanical irritation, this assumption would certainly not suffice. It is very important to study these matters, because the progression of acute inflammations is one of the most serious processes in the whole of pathology. If, from an already existing inflammatory focus, a phlogogenous material enters the blood, and thence acts specifically upon any organ for which it has an affinity, the secondary inflammation produced in this way is called "metastatic;" such metastatic inflammation may, however, occur in another and much rougher manner, by means of infected blood-clots which come from the veins; of these we shall speak more particularly in the section on thrombosis, embolism, and phlebitis. The non-traumatic inflammations may terminate in resolution, in firm organization of the inflammatory products, in suppuration, or in gangrene. We shall, however, not make any more general remarks on this subject, but shall now proceed to the inflammations of the separate tissues.

1. *Acute inflammation of the cutis.*

The simple forms of acute inflammation of the cutis (maculæ, wheals, papules, vesicles, pustules), which are embraced under the common name of the "acute exanthemata," belong to internal medicine. Only the erysipelatous inflammations, furuncle and carbuncle, are taken cognizance of in surgical works. Whilst the

so-called acute exanthemata are supposed to be always preceded by blood-poisoning and to be always of "deuteropathic" origin, the theory with regard to the above-mentioned forms of dermatitis is generally, that they are purely local affections and of "protopathic" origin; we shall hereafter see how far this is correct. I must, however, here remark that very frequently the cutis becomes secondarily affected by extension, to adjoining parts, of the inflammatory processes, especially of those which arise first in the subcutaneous cellular tissue, in the muscles, or even in the periosteum and the bones.

(*a.*) The erysipelatous (ἐρυσίπελας, red-looking inflammation of the skin, from ἐρυθρός, red, and πέλας, skin) inflammation is situated principally in the papillary layer and in the rete Malpighii of the cutis. The local symptoms are great and sharply defined redness and œdematous swelling of the skin, pain on the least touch, and subsequent desquamation of the epidermis; these are sometimes accompanied by very violent fever quite out of proportion to the extent of the local disorder. The disease may last from one day to three or four weeks; every part of the skin may be attacked, but spontaneous erysipelas is particularly common in the face and neck. According to the view of many pathologists, erysipelas of the face and head should, like scarlet fever, measles, &c., be regarded as a symptomatic inflammation of the skin, that is, the local process is looked upon as only one symptom among others of the acute general disorder. Were this so, surgery would have as little to do with erysipelatous inflammation as with scarlet fever, measles, &c., but inasmuch as it occurs especially in wounded persons and particularly often around wounds, and is therefore one of the accidental wound diseases, we must study it yet more minutely. According to my own view, which coincides with that of the majority of modern clinical observers, traumatic erysipelas is not a symptomatic inflammation of the skin, but a true dermatitis always due to infection, such infection proceeding either from some inflammatory or septic focus contained in the patient's own body (such as blood in a state of putrefaction enclosed in a portion of the wound), or of external origin and gaining access to the body from without. We shall hereafter speak more in detail of this disease when treating of the accidental diseases of wounds, and we will therefore be content here with having just alluded to it on account of its anatomical connection with the other forms of dermatitis.

(*b.*) Furuncle or Phlegmon is a peculiar form of inflammation of the cutis, having generally a typical course. To many of you it may be known from personal observation. The first thing that happens is the formation of a nodule in the skin as large as a pea or bean, of a red colour and somewhat sensitive. Soon a small white spot is found at its apex, the swelling extends round this centre, and becomes usually about the size of half-a-crown, or rather larger; sometimes the furuncle remains quite small, only about as large as a cherry; the larger it is, the more painful it becomes, and it may excite feverishness in persons of irritable habit. If left quite to itself, towards the fifth day the central white point becomes loosened in the shape of a small plug, and pus, mixed with blood and detached shreds of tissue, escapes on slight pressure; three or four days later on, the suppuration ceases, the swelling and redness gradually disappear, and a punctate, scarcely visible cicatrix finally remains.

We very rarely have an opportunity of examining such furuncles in their earliest stage, as they can scarcely ever be a fatal disease; but as far as one can see of the development, and on incision into a furuncle, the death of a small portion of cutis seems to form the starting-point and the centre of an inflammatory process in which the blood finally stagnates in the dilated capillaries, and the tissue of the cutis, from plastic infiltration, is partly converted into pus and partly detached in a gangrenous state. The opinion has already often been expressed that the necrosed centre of a furuncle is a cutaneous gland; according to the observations of Kochmann, it is very often a sweat-gland, in and around which fibrinous inflammation forms, the sebaceous glands also being liable to similar morbid processes. The essential peculiarity is, that such a centre of inflammation exhibits, as a general rule, no great tendency to spread diffusely, but the whole process runs a circumscribed course, and is wont to terminate with the detachment of the little plug as above described.

There is no doubt that in very many cases the formation of single furuncles is due to purely local causes. Some parts of the skin where the secretion of the cutaneous glands is particularly copious, such as the perinæum, the axillæ, are especially liable to the formation of furuncles. These also occur very frequently in persons who have very large sebaceous glands, and so-called pimples, grubs, or comedones. But undoubtedly there are also general conditions of the body, diseases of the blood, which predispose to the formation of numerous furuncles in various parts of the body. This morbid

diathesis is called Furunculosis; it may, if of long standing, be very exhaustive to the organism: it causes emaciation and loss of strength from pain and sleepless nights, and may prove fatal to children and old weakly persons. Among people in general the formation of furuncles is associated with fulness of blood and corpulence, and it is believed that fatty articles of food predispose to it. In my country, Pomerania, they call such persons who suffer much from pustules and furuncles "suppurative" (*süchtig*). I very much doubt the truth of the supposition that fatty articles of food particularly predispose to the formation of furuncles. You will often meet with cases of furunculosis in very miserable atrophic children and in emaciated sickly people, and although the imperfect attention to the skin has to be made allowance for, yet it is by no means the sole cause of the origination of furuncle. It is true that very well-fed butchers are very liable to furuncles, but this may be explained in some other way, rather than by attributing it to superabundance of fatty food, for it can not unfrequently be proved that in them the furuncles are due to poisoning from the carcases of dead animals, or some morbid matter from diseased animals; at least some such cause as this should always be sought for. On the other hand, I think it is going too far to assume that every furuncle is caused by infection, and is always to be regarded as one symptom out of many of a generally suppurative diathesis, of a pyæmia. Kochmann supposes that general furunculosis is usually a symptom of diabetes; we shall shortly allude further to this subject when speaking of carbuncle.

The treatment of single furuncles is very simple. Attempts have been made to cut short the process and prevent suppuration by the early application of bladders of ice; this, however, rarely succeeds, and it is, moreover, a tedious process, seldom in favour among patients. I think that the best plan always is to expedite the suppuration as much as possible by warm moist applications, and, if the furuncle does not spread too much, quietly to wait for the separation of the central plug, then gently to squeeze out the furuncle, and to do nothing more. If the furuncle be very large and the pain very great, we may make a simple incision, or a crucial one, through the tumour; the escape of blood and the more rapid occurrence of suppuration will then assist the natural course of the process. Owing to the inconvenience of poultices, which necessitate confinement to the house and prevent work, many persons use

plasters made of soap, or of honey with meal or saffron, and such like; these are credited with some mysterious properties for drawing out the pus; I have not found that these plasters do any harm, and therefore do not raise any objection to their use, but they certainly do not possess any peculiar advantages.

General furunculosis is a very difficult disease to deal with successfully, especially as we know little of its cause. As a general rule, we give preparations of quinine, the mineral acids, and iron internally. Besides these, general warm baths continued for some length of time are to be recommended. Also, a strictly regulated diet, nourishing animal food, with good wine, is particularly advisable. The separate furuncles are to be treated as above described.

(*c.*) *Carbuncle and carbunculous inflammation.—Anthrax* (Carbunculus, Kohlenbeule, a burning swelling, the subsequent Latin translation comes from the older word ἄνθραξ, a coal) resembles anatomically a group of several furuncles lying close to one another. The whole process is more extensive and intense, and more inclined to gradual progress, so that other parts are involved by the inflammation continuing to spread. Many carbuncles, like most furuncles, are originally a purely local disease; their chief seat is the hard skin of the back, especially in old persons. Their origin and the way in which they spread are the same as in furuncle, but soon a large number of white points form near each other, and around these the swelling, redness, and pain increase, in many cases so incessantly that the whole extent of the carbuncle may attain the size of a soup-plate, and whilst the detachment of the white gangrenous plugs of skin is going on in the middle portions, the process not unfrequently extends at the periphery; this tendency to peripheral spreading is characteristic of carbuncle, and distinguishes it clinically from furuncle. A much larger quantity of gangrenous tissue is detached in carbuncle than in furuncle. After the separation of the plugs of cutis the skin appears perforated like a sieve, but not unfrequently afterwards suppurates, so that a carbuncle is always followed by a very large cicatrix. But even when the process is most intense, it is almost always confined to the skin and subcutaneous cellular tissue; it rarely happens that fasciæ and muscles are destroyed by the gangrene, so that in a large carbuncle in the neighbourhood of large arterial trunks, destruction of the walls of the vessels is not so liable to occur as might be feared. This is shown by experience.

This confinement of the morbid process to the skin and subcu-

taneous cellular tissue is very characteristic of the fibrinous (diphtheritic) inflammations, so that on this account, and also because of the hard infiltration and the constant death of the tissue once infiltrated, I do not hesitate to designate carbuncle as a diphtheritic inflammation of the skin. I have hitherto had no opportunity of examining for the presence of micrococci in the fluid recently expressed from carbuncles; the discovery of a few vegetable organisms of this kind in the gangrenous and exposed shreds of tissue, cannot prove anything with regard to the origination of anthrax from micrococci. Kochmann thinks that carbuncles, like furuncles, arise originally around a sweat-gland, or simultaneously around several glands lying near each other. J. Neumann distinguishes between a carbuncle of the cutaneous glands and a carbuncle of the cellular tissue. I cannot decide whether such a distinction can be made, for I have not had sufficiently frequent opportunities of seeing carbuncle in its primary stage.

After the extensive loss of the cellular tissue and the final arrest of the process in the periphery, healthy and usually very luxuriant granulations are formed; healing goes on in the usual manner, the time required corresponding to the size of the granulating surface.

Carbuncle occurring on the back is usually a tedious and painful affection, though it rarely causes death. There are, however, cases, especially when the carbuncle, or a diffuse carbunculous inflammation, occurs on the face or head, which at an early stage are associated with symptoms of a septic, or as was formerly called of a "typhoid," character (not always with increase of temperature); such cases are very dangerous, and usually terminate fatally (malignant carbuncle, malignant pustule). It is not every carbuncle of the face that possesses this malignant character; some run the usual course, and leave only a disfiguring cicatrix; but as it is very difficult, often indeed impossible, to predict at the commencement how the case will turn out, I recommend you always to give a careful prognosis. I have had, unfortunately, such sad experience of these carbuncles of the face, that any case of the kind makes me very careful and anxious as to the ultimate issue. Let me tell you briefly of a few such cases.

A young, powerful, healthy man was, while on a journey to Berlin, attacked without known cause by a painful swelling in the lower lip; this increased rapidly and soon spread over the whole

lip, while the patient became very feverish. The surgeon who was called in applied poultices, and did not appear sufficiently to appreciate the gravity of the complaint, as he failed to visit the patient for two days. On the third day the face was greatly swollen, and the patient had had a violent attack of shivering, and was, moreover, quite delirious when admitted into the surgical wards. I found the lip dark bluish-red in colour, and dotted over with numerous white gangrenous patches of skin. A great many incisions were at once made; the wound was dressed with chlorine water, cataplasms applied, and a bladder of ice placed on the head, as meningitis was setting in. As soon as I saw the patient, I declared his condition to be hopeless; he soon fell into a deep stupor, and died twenty-four hours afterwards, four days after the commencement of the carbuncle on the lower lip. Unfortunately, an autopsy was refused.

I will mention another case. A student in Zurich received a sword-cut over the left parietal bone. The wound healed without any remarkable symptoms, but some time elapsed before it perfectly closed. A small open wound remained for a long time, but was so inconsiderable that the patient thought nothing of it. Violent efforts while fencing, and perhaps taking cold afterwards, may have been the exciting causes of the following catastrophe. The young man awoke one morning with rather severe pain in the cicatrix and general feeling of illness; a rosy redness and, at first, moderate swelling of the scalp led me to suspect an attack of simple erysipelas of the head. The fever, however, increased in an unusual manner, without the redness spreading over the whole of the head. An attack of shivering came on, and the patient became violently delirious. When brought into hospital on the third day, I found in the neighbourhood of the cicatrix a number of small white points which at once showed me that I had to deal with a case of carbunculous inflammation, and as the patient was quite unconscious, and a complication with inflammation of the membranes of the brain appeared from various reasons very probable, I held out very little hope of recovery, gave the necessary directions, but found on the next day that the patient was dead. The autopsy showed several white gangrenous points in the inflamed cicatrix of the scalp; on further examination the neighbouring veins were found plugged up with clots, and all along their course the surrounding cellular tissue was swollen, and in places dotted over with points of pus. I could

follow this diseased condition of the veins anteriorly as far as the orbit, but stopped here, not wishing to injure the eye. After opening the skull, as soon as the brain was removed, a moderately inflamed spot about as large as half-a-crown was found in the left anterior cranial fossa; the disease affected both the dura mater and the pia mater, and in some degree involved the surface of the brain substance. There was no doubt that the inflammation, proceeding from the cicatrix on the head, had extended along a frontal vein into the cellular tissue of the orbit, and thence through the foramen opticum and sphenoidal fissure into the skull.

The inflammation here described cannot exactly be termed anthrax, but rather a form of inflammation of the skin and cellular tissue similar to the process in that disease, and which, according to my present experience, I should like to call diphtheritic phlegmon; the erysipelatous redness associated with it also accords with diphtheritis. We shall hereafter have more to say on this subject.

In many cases of malignant carbuncle of the face, we shall find on very careful examination an extension of the inflammation into the cranial cavity and a consequent disease of the brain, as in the case just given. But I must mention to you that the extent of this inflammation, as found in the dead body, is in no proportion to the great violence of the general symptoms, so that the latter are by no means explained by the post-mortem appearances. Indeed there are cases, and sometimes those running the quickest course, where death occurs without our being able to find any disease in the brain. There is here plenty of room for hypothesis; the rapid violent course and the quick transition of carbunculous inflammation into gangrenous disintegration suggest the possibility of a rapidly occurring decomposition of the blood, of which the carbuncle itself may be regarded either as the consequence or the cause. But inasmuch as the decomposition of the blood must also have its cause, it has been supposed that perhaps an insect which has alighted on some carrion, or on the nose of a glandered horse, or a cow with carbuncle, &c., may then settle upon a man and thus infect him; you will hereafter learn that malignant carbuncles especially result from the poison of carbunculous cattle. I know of no cases in which this process has been actually demonstrated, but I do not consider it impossible that such instances may occur; this assumption is supported by the fact that these carbuncles are particularly prone to occur on parts of the body which are usually exposed. At all events, the violent fever

and the fatal blood-infection are the consequences of the local process; we must therefore assume that in these carbuncles, under certain conditions not exactly understood, materials of a peculiarly intense poisonous nature are formed, which when absorbed into the blood cause death. But the exciting cause of this malignant carbuncle is, in the majority of cases, extremely obscure. The great difference in the general symptoms in anthrax harmonises well, according to my present experience, with the assumption that this disease belongs to the category of the diphtheritic processes, one great characteristic of which is that their local extent is in no sort of proportion to the intensity of the general toxic symptoms. I do not know whether paralyses, which are so frequently seen after diphtheritis of the pharynx and larynx, occur after anthrax. Carbuncles occur in diabetes mellitus and uræmia, just as sugar is observed in the urine of persons otherwise healthy in whom furuncles and carbuncles are spontaneously developed (Wagner); these are puzzling facts. Possibly these latter observations are to be explained by the fact that patients with carbuncle were previously only apparently healthy; they may possibly have had slight diabetes without this being known either to them or to their medical attendant. Fortunately, carbuncles are not very common; even the simple benignant carbuncles are so rare that in the extensive surgical policlinic of Berlin, where every year from five to six thousand patients came before me, I saw perhaps only one carbuncle every two years. In Zurich also they were extremely rare. I can form no judgment as to the frequency of this disease here in Vienna, for these cases are usually relegated to the department for diseases of the skin. The diagnosis of ordinary carbuncle is not difficult, especially when the complaint has been once seen; diffuse carbunculous inflammation can only be recognised after a period of observation; it looks, at first, like erysipelas.

The treatment of carbuncle must be very energetic, if we would prevent the spread of the disease. As in all inflammations tending to gangrene, numerous incisions should be made early, in order that the decomposed putrid tissue and fluids may escape. In every carbuncle, therefore, you should make large incisions through the entire thickness of the skin; these should cross each other and be long enough to completely divide the infiltrated integument, and extend as far as the healthy skin. If these prove insufficient, you must make a few more incisions, particularly wherever the gangrene

of the skin is indicated by the white points. The bleeding from these incisions is relatively inconsiderable, the blood being coagulated in most of the vessels in the carbuncle. Lint dipped in chlorine water should be placed in the incisions, and renewed every two or three hours. When the tissues begin to separate, you should draw out every day with a pair of forceps the semi-detached shreds and cut them off without causing bleeding, and thus endeavour to expedite as much as possible the cleansing of the wound. Vigorous granulations will soon show themselves in places; at last the remaining shreds become detached, leaving a honey-combed porous granulation surface, which soon becomes level and afterwards cicatrizes in the usual way, so that its healing, like that of other granulating surfaces, requires only a little assistance from nitrate of silver. With regard to malignant carbuncle, the local treatment is the same as that just described. All we can do for the affection of the brain which so rapidly supervenes is to apply a bladder of ice to the head. As internal remedies we generally give quinine, acids and other antiseptics. Unfortunately, I must confess that the results of this treatment are exceedingly small; in my own experience I have not met with a case in which it succeeded in averting the fatal issue when septicæmia was to any extent developed, which is the more disheartening, inasmuch as these malignant carbuncles generally attack young and vigorous persons. Even when the termination is favorable as regards life, there will certainly be considerable loss of skin and great disfigurement, especially in carbunculous inflammation of the eyelids, or of the lower and upper lip, as these parts are in a great measure destroyed by gangrene. Even very early incision, excision, and burning out of the carbuncle, are of little effect as regards the further course of the disease, as I have been able to prove to myself in a few malignant cases. But you should not be deterred by these hopeless prospects of treatment from making free incisions at an early period, for cases do occur in which carbuncles on the face run the usual course, although associated at the commencement with violent fever. French surgeons have reported some favorable results from burning out malignant pustules at an early stage.

2. *Acute Inflammation of the Mucous Membranes.*

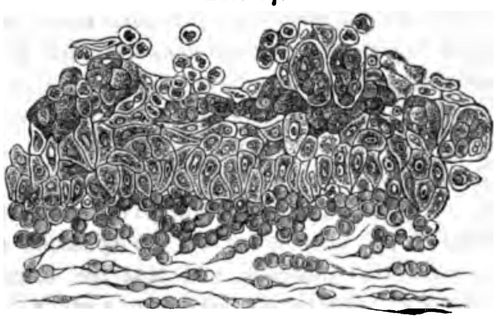
Whilst traumatic inflammation of the mucous membranes presents no peculiarities, the "acute catarrh," or the "acute catarrhal

inflammation" is a form of disease peculiar to these membranes, and which is characterised anatomically by great hyperæmia, somewhat œdematous swelling, and copious discharge of a secretion at first serous, and subsequently muco-purulent, and is most frequently caused by taking cold and by infection. "Blennorrhœa" (from βλέννα, mucus, and ῥέω to flow) is an increase of the catarrh to such a degree that pure pus is discharged in large quantities. Catarrh and blennorrhœa may become chronic. Even simple observation of exposed mucous membranes affected with catarrh, shows that this process may continue for a long time, and be very intense, without the substance of the membrane becoming much involved; the surface remains hyperæmic and swollen, somewhat thickened and puffy; in rare cases there is superficial loss of epithelium with small breaches of tissue (catarrhal ulcers), but it is only in extremely rare cases that these are followed by more extensive destruction. This observation is supported by post-mortem examination and histological investigation. The view which now obtains is, that in catarrh there is only a more rapid detachment of the epithelial cells, which approach the surface as pus-cells, and that the connective-tissue layer of the mucous membranes takes no part in the process. Although many attempts were made to discover processes of division in the cells of the deeper epithelial layers of mucous membranes affected with catarrh, they were unsuccessful until at last Remak, Buhl, and Rindfleisch discovered large mother-cells in the epithelial layers of such membranes.

It was most natural to interpret this observation by supposing that the mother-cells were formed from the epithelial cells by endogenous division of the protoplasm, and that subsequently the brood of cells became exposed (as pus-cells) by the bursting of the membrane of the mother-cells. In opposition to this view it was repeatedly asserted that in this case the mother-cells would be constantly found on catarrhal mucous membranes, whereas the fact is that they are discoverable only at the commencement of the affection, and then only in small numbers; their appearance therefore has in recent times been explained quite differently. Steudener and Volkmann first advanced the opinion that in this case the young cells do not originate from older ones, but that they may enter the latter from without under certain favorable mechanical conditions, and that they have nothing to do with the origin of the pus. Although this assertion is very difficult to prove, yet after repeated consideration

and bringing together known facts, it seems to me to be very probable. This is not the place to go into the details of this subject, although, as it can be demonstrated by the cinnabar method that the white blood-cells escape from the vessels of the inflamed mucous membrane and not only pass between the epithelial cells, but are also found as pus-cells in the catarrhal secretion, I am inclined to think that the pus in catarrh has the same origin as other pus, that is to say, that it comes directly from the blood.

FIG. 67.



Epithelial layer of a conjunctiva affected with catarrh. After Rindfleisch. Magnified about 400 diameters.

Besides the catarrhal inflammation, there are other forms peculiar to mucous membranes, viz. the "croupous" (from "croup;" häutige Bräune) and the "diphtheritic" (from διφθέρα, a skin). In inflammation of the mucous membranes, if the inflammatory products (cells and transudation), which appear on the surface, form fibrinous material and thus become an adherent membrane, which after some time dissolves into mucus and pus, or is removed by the pus which is produced beneath it by the mucous membrane, this is called a "croupous inflammation;" the mucous membrane with its epithelium remains intact in this affection, and perfect restoration ensues. Diphtheria is exactly similar to the process above described, but not only does the fibrinous layer adhere more firmly to the tissue, but the serum which permeates the substance of the diseased mucous membrane also coagulates; in this way the circulation of the fluids of the tissue and of the blood is impaired to such a degree that sometimes the diseased portion becomes completely gangrenous. The general disorder, the fever in extensive croupous

inflammation (for example, of the finest bronchi and alveoli of the lungs, croupous pneumonia), may be very severe, but in diphtheria it has more the character of a septic infection; diphtheria is therefore a far more malignant disease. The mucous membrane of the pharynx and trachea is often exposed to both forms of the disease. The conjunctiva, which is so very frequently affected by catarrh, may be attacked by diphtheria, but seldom suffers from the croupous form of inflammation. The mucous membrane of the intestinal canal is only rarely the seat of these affections, which also seldom invade the mucous membrane of the genital organs, which are so often affected by contagious blennorrhœa (Tripper; gonorrhœa, from γόνος, semen).

Micrococci are almost always found in large quantities in the diphtheritic layer covering mucous membranes; it is not yet proved that these organisms are of a peculiar kind and are the cause of the disease, though this has been frequently asserted. It is extremely probable that the contagious matter of diphtheria may depend upon these vegetable organisms, or may penetrate into them. We shall hereafter return to this question when treating of a form of ulcerous diphtheria of wounds, the so-called hospital gangrene.

3. *Acute Inflammation of the Cellular Tissue.*

Phlegmonous inflammation.—This term involves a pleonasm, for "φλεγμόνη" by itself means "inflammation;" it is, however, practically so exclusively employed to designate inflammation of the cellular tissue leading to suppuration, that every surgeon knows what it means; another name for the same disease is pseudo-erysipelas; this is just as much in use, but it seems to me to be less distinctive. The common English expression "cellulitis" instead of "inflammatio telæ cellulosæ" is certainly short and convenient, but it involves too great a contradiction to our present idea of the "cellula," so that I cannot recommend it. The causes of these processes of inflammation are, in very many cases, exceedingly obscure; a violent cold can rarely be proved to be the exciting cause; such inflammations might often enough be caused by infection even with the skin entire; this, however, is only an hypothesis. We have already met with these progressive acute inflammations as accidents attending injuries, particularly as a consequence of local infection

from shreds of tissue becoming gangrenous in contusions and contused wounds. Spontaneous inflammation of the cellular tissue most frequently occurs in the limbs, and more often above than beneath the fasciæ; it is especially prone to occur on the fingers and hand, where it is termed "panaritium" (a corruption of paronychia, inflammation about the nail, from ὄνυξ), and also "panaritium subcutaneum," to distinguish it from the deeper-seated inflammations also occurring in the fingers and hand. If the inflammation attacks the neighbourhood or the bed of the nail, it is termed "panaritium subungue." Let us take as an example the symptoms of a phlegmon on the forearm; it usually begins with pain, redness, and swelling of the skin, generally associated with violent fever; the skin is somewhat œdematous and very tense. With such a commencement, which always indicates acute inflammation of the arm, the seat of the mischief may vary very much as to its depth, and during the first few days you will not always be able to decide whether you have to deal with an inflammation of the subcutaneous cellular tissue, with a perimuscular inflammation beneath the fasciæ, or even with inflammation of the periosteum or of the bone. The greater the œdema, the more severe the pain, the less the redness of the skin, the more intense the fever, the greater is the probability that you have before you a deep-seated inflammatory process which will terminate in suppuration. If the inflammation affects only the subcutaneous cellular tissue, and if, as is generally the case, suppuration occurs (although it may terminate in resolution), this is indicated by increased redness and evident fluctuation, becoming perceptible at one spot in the course of a few days. Then the pus either escapes through an opening of spontaneous origin, or is let out by an incision. If the inflammation affects portions of the body where the skin, and especially the epidermis, is particularly thick, as in the hands and feet, there will, at the commencement, be but little redness visible, this being hidden by the very thick horny layer of the epidermis. Great pain, and a peculiar feeling of throbbing and tension, in the inflamed part indicate the formation of pus under the skin.

In some cases, while these changes are going on, a portion of the skin becomes gangrenous, its loss of vitality being due to the disturbance of the circulation by the intensity of the inflammation. The fasciæ are also sometimes threatened by these inflammations; they then appear through the openings in the cutis as large, white,

consistent, filamentous shreds. This is particularly the case in inflammations under the scalp, which often spread over the whole of the skull; the entire epicranial aponeurosis may thus perish.

Let us now pass to the more minute anatomical changes which take place in acute inflammation of the cellular tissue. We shall not now return to the controversy as to whether vessels, tissues, or nerves are first affected in the inflammatory process, but shall only allude to what we can observe on direct anatomical examination. A series of observations on the dead bodies of persons who have died from such inflammations, or on limbs which have been amputated when thus affected, and in which, in various cases, the cellular tissue is found in every stage of inflammation, give us tolerably complete information with regard to these processes. The first things that we find are, distension of the capillaries, and swelling of the tissue by serous exudation escaped from the vessels, and at the same time, varying according to the stage, copious plastic infiltra-

Fig. 68.

Inflammatory infiltration of the connective tissue of the prepuce. Cellular infiltration of the tissue; conversion of the connective tissue into inflammatory new formation. The filamentous fibrillary condition of the tissue is almost entirely lost; the walls of the vessels are relaxed, and as though perforated. Magnified about 500 diameters.

tion; that is to say, the connective tissue is traversed by an enormous number of young cells. This is then, at the commencement, the anatomical condition of the tissue under the œdematous,

swollen, much reddened, and very painful skin. Subsequently the great accumulation of cells in the inflamed connective tissue and fat becomes more and more prominent. These tissues become very tense, and there is stagnation of blood in the vessels at various points, the circulation at some places completely ceasing. This stagnation of the blood, which at first causes a dark blue colour and then a whiteness of the affected tissue in consequence of rapid discoloration of the red blood-cells, may extend so far as to cause extensive gangrene of the tissue, a termination to which we have already alluded. This, however, does not occur in the majority of cases, but, while the cells increase, the fibrillary intercellular substance disappears and dies, partly in the shape of small shreds and particles, partly by gradually assuming a gelatinous consistence and finally becoming quite fluid.

As these changes progress, the whole of the inflamed spot is finally converted into pus, that is, to fluid tissue, consisting of cells with some serous intercellular fluid, which is mixed with many shreds of dead cellular tissue. Suppose that the whole process commences in the subcutaneous cellular tissue, extends in all directions, most rapidly where the tissue is most vascular and relaxed, the purulent destruction of tissue, the suppuration, will by degrees extend to the cutis from within, perforate it at some point, and then through this perforation the pus will escape externally. When this occurs, the process often ceases to spread. The tissue surrounding the purulent collection is copiously traversed by cells, and highly vascular; it resembles anatomically a granulation surface (without showing always distinct granules), which therefore lines the whole cavity. When the pus has all escaped, the walls of the cavity come together and unite tolerably rapidly in most cases. The plastic infiltration continues for some time longer, and the skin, therefore, remains firmer and stiffer than usual. Gradually, however, the normal state becomes re-established, partly by disintegration and absorption of the infiltrating cells, and partly by conversion of the same into connective tissue.

You will readily perceive that there is no great anatomical difference between the processes as such, whether diffused or circumscribed; the finer changes in the tissue are exactly the same in a diffuse as in a circumscribed inflammation of the subcutaneous cellular tissue. In practice, however, a distinction is made between *purulent infiltration* and *abscess*. The first term explains itself; by *abscess* we

are accustomed to understand a circumscribed collection of pus, and thereby to exclude from our idea any further spread of the inflammatory process; *hot abscesses* are those which form rapidly from acute inflammation, in contradistinction to *cold abscesses* or those which result from a chronic inflammation. The subjoined figure may give you a clearer idea of the process of the formation of abscess (Fig. 69).

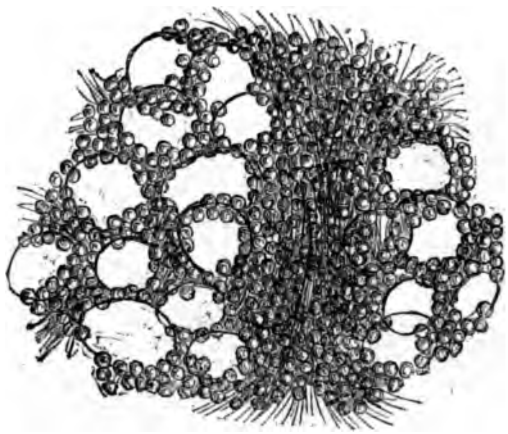
FIG. 69.

Purulent infiltration of the connective tissue of the cutis, the pus becoming confluent and forming an abscess in the middle. A diagram. Magnified about 500 diameters.

You see here how the young cells have become infiltrated into the tissue while the intermediate substance constantly decreases, how also in the middle of the drawing, in the centre of the inflamed area, groups of cells unite and form a collection of pus; every abscess has consisted at first of such separate collections of pus, it increases by peripheral extension of the suppurating process. Formerly it was supposed that in all places where the pus-cells thus appeared collected together into groups they were all to be regarded as the products of the connective tissue-cells; according to the views now held there is no doubt that these young cells are almost all of them white blood-cells which have escaped, and which only from mechanical causes sometimes collect together in a peculiar manner in groups. The fat, which is generally contained in abundant quantity in the subcutaneous cellular tissue, usually perishes in the acute inflammatory

processes, the fat-cells being to some extent crushed by the masses of new cells, and the fat itself becoming fluid; subsequently, it is occasionally found in the form of drops of oil mingled with the pus. In this preparation you may see the microscopic appearance in inflammation of the adipose tissue (Fig. 70).

FIG. 70.



Purulent infiltration of the adipose layer. Magnified 350 diameters. From a preparation hardened in alcohol.

In examining such preparations we not unfrequently find coagulated filaments, as in coagulated fibrine, infiltrated into the tissue; possibly these are formed at the commencement of the inflammation as previously described, but it is also possible that these filaments belong only to the fully formed pus; in our preparation they may, perhaps, be principally artificial productions due to the alcohol.

I must call your especial attention to the fact that, until the process is arrested, there is always a progressive softening of the tissue infiltrated with pus, a suppuration, in contradistinction to the fully developed granulating surface, from which there is a superficial secretion of pus, without any loss of tissue being caused thereby. All suppurative parenchymatous inflammations have a disorganizing (deleterious or destructive) effect upon the tissue.

As regards the relation of the blood-vessels to the new formation of the young tissue and its speedy disintegration and liquefaction, it has been already mentioned that they are at first dilated, and

that then the blood stagnates in them; if the circulation be quite arrested in certain portions of tissue, in which case the coagulation in the veins sometimes spreads to a very considerable distance, the walls of the vessels and the clot suppurate or break up into shreds, as far as the boundary where the circulation again begins. As we have previously seen when studying the detachment of necrosed shreds, vascular loops must form on this border of the living tissue; the whole inner surface of the cavity of an abscess, with regard to the arrangement of its vessels, resembles therefore a granulating surface folded up in the form of a sack.

With regard to the lymphatic vessels, we may conclude from analogy that in the case before us, as in the neighbourhood of wounds, they become closed by the inflammatory new formation;

Fig. 71.

Vessels (artificially injected) from the walls of an abscess artificially produced in the tongue of a dog. Magnified 25 diameters.

special investigations on this subject would be very desirable. As soon and as long as an abscess is surrounded by a vigorous layer of tissue infiltrated with plastic material, from reasons already mentioned, purulent and putrid substances will not be readily absorbed from the cavity of the abscess. I can give you practical evidence of this; if in the wards you smell the pus of an abscess

from the neighbourhood of the rectum or from the mouth, it will be found to have an exceedingly penetrating putrid odour, and yet it is not absorbed by the walls of the veins, or it is so only in extremely small quantities; symptoms of general poisoning by septic matter very seldom occur. At the commencement, however, of the inflammatory process, and then at a later period, if it be accompanied by rapid destruction of tissue, as in many progressive inflammations around contused wounds, and in spontaneous phlegmon of the subcutaneous cellular tissue, &c., — the lymphatic vessels not being as yet stopped up by new formation of cells and tissue— organized inflammatory new formation possibly does not occur at all, or only at a subsequent period when the gangrenous destruction is becoming defined; but before this occurs the products of destruction of the decomposing tissue find their way into the open lymphatic spaces, and act upon the blood and produce fever.

Although the inflammation of the cellular tissue may occur occasionally at any part of the body, it is most frequent in the hand, forearm, parts about the knee, foot, and leg. Lymphangitis often accompanies phlegmon, and frequently precedes its spread; of this we shall speak subsequently when treating of accidental diseases of wounds.

The intensity and duration of the fever which accompanies these inflammations, depend upon the quantity and quality of the material thus absorbed. At first, in a certain degree, a large quantity of such inflammatory products finds its way into the blood, hence usually at the commencement there is violent fever, sometimes with shivering; as the inflammation progresses, the fever continues, and it ceases when the further absorption of the inflammatory product is arrested by the above-described metamorphoses of the tissue; the process then stops and the formation of abscess is complete. The quality of the inflammatory material formed in inflammations of the cellular tissue certainly varies greatly; there are cases of phlegmon, for example, deep in the neck in old people, in which such intense inflammatory poisoning ensues that the patients speedily die without the supervention of other symptoms. It is the same therefore as with carbuncles, some cases of which cause but little fever, others produce a fatal septic fever. If the phlegmon has been caused by a dangerous poison, such as that of glanders, we cannot, after the experience we have had, be surprised at the fatal issue; but in the case of those phlegmons which are of spontaneous origin, and have

arisen without known cause, it is always very mysterious why some cases should be so extremely severe, while most of them are relatively slight.

The prognosis in phlegmonous inflammations varies very greatly according to the position, extent, and cause. While the disease occurring as a metastasis in a general inflammatory or purulent diathesis, or as a consequence of glanders poison, gives little hope of cure, while deeply seated abscesses, for example, in the walls of the abdomen, and in the pelvis, are at least very slow in their course and may be dangerous to life from their locality, or may impair the functions of the parts by destruction of fasciæ, tendons and skin, most cases of phlegmon on the fingers, hand, foot, forearm, &c., are only slight diseases of short duration, although very painful. The more rapidly suppuration sets in, and the more circumscribed the whole of the inflammatory area, the better the prognosis.

With regard to treatment, at the commencement of the disease we endeavour, if possible, to arrest the development of the process, that is, to obtain the earliest possible complete absorption of the serous and plastic infiltration. For this purpose there are various remedies; in the first place, the external application of mercury; the whole of the inflamed portion of skin is covered over with a thick layer of mercurial ointment, the patient is kept in bed, and the inflamed extremity is enveloped in warm moist cloths or covered with large poultices. It is, in addition, very important to elevate the inflamed parts as much as possible; the arm may be suspended vertically by means of an adhesive plaster-dressing as Volkmann has proposed; the return of the blood is thus greatly facilitated, and the stagnation in the inflamed parts diminished; the efficacy of this position has been for a long time undervalued. The application also of ice may be adopted from the commencement, if the whole inflamed part can be covered with several bladders; there is, however, no certainty of a successful result, and the cold is very unpleasant to many patients. Compression, by covering the parts with adhesive plaster or bandages, would likewise be an effective remedy for aiding absorption, but it is little used in these inflammations; in the first place, because the compression of these inflamed parts causes much pain, and in the second place, because the remedy is not altogether free from danger, as gangrene may be easily induced by a little too much pressure. If the process does not subside soon after the employment of the above-mentioned remedies, but all the symptoms

rather increase, we must give up hope of a termination in resolution, and use means to expedite the suppuration, which we can now no longer prevent; the application of moist warmth is particularly suitable for this purpose, especially in the form of warm moist dressings. As soon as distinct fluctuation is detected at any spot, we do not as a rule leave nature to make the opening, but divide the skin to give vent to the pus; if the suppuration extends under the skin for a considerable distance, we make openings in several places; at least I prefer these to the huge incisions through the skin, from the elbow to the hand for instance, because in the latter case the skin gapes very widely and takes a very much longer time to heal. If the escape of pus goes on in a normal manner from the openings which have been made, extreme cleanliness is the only thing necessary; local warm baths will be found very convenient and of great service. You will often hear it said that early incisions into phlegmons may prevent extensive gangrene of the skin or the occurrence of suppuration. Unfortunately, I am unable to confirm this assertion, for I have often enough seen the occurrence of gangrene and suppuration of the skin even after early incisions; according to my observations this is far more dependent upon the intensity of the inflammatory process than upon the tension of the skin due to the subcutaneous accumulation of pus. Nevertheless I think that early incisions are very proper in phlegmons, because it appears to me that the advance of the process may sometimes be checked by carefully pressing out the serum from the inflamed tissue.

While the opening of abscesses of the subcutaneous cellular tissue is a very simple matter, and unattended by danger, "oncotomy" (from ὄγκος, protuberance, a tumour) in deep-seated abscesses requires great attention according to the anatomical relations of the locality; the diagnosis, for instance, in these suppurations of the neck, pelvis, and abdominal walls may present great difficulties, and can generally be positively determined only after a long period of observation; nevertheless it may be desirable to evacuate the abscess at an early period, partly to relieve the patient and partly to avoid a spontaneous opening perhaps into the abdominal cavity. In such cases we must not at once plunge in a scalpel, but should feel our way with the knife, dividing layer after layer until we reach the fluctuating covering of the abscess; then a probe should be cautiously introduced, and the opening dilated by separating the blades of the

forceps introduced into the abscess, so as to avoid all bleeding from the deeper parts. Sometimes, from decomposition of the pus, so much gas forms in an abscess as to yield a tympanitic sound on percussion; such putrid abscesses should be early opened, and afterwards syringed out and dressed with chlorine-water, solutions of acetate of alumina and of carbolic acid.

4. *Acute Inflammation of the Muscles.*

Protopathic acute inflammation of the muscular substance is relatively rare. It occurs in the muscles of the tongue, in the psoas, pectoral and gluteal muscles, and in those of the thigh and calf; it generally ends in the formation of abscess, although it has also been observed to terminate in resolution. Metastatic muscular abscesses are very frequent in glanders. With regard to the histological conditions, the interstitial connective tissue of the muscles, the perimysium, is here, as in the traumatic myositis, the principal seat of the purulent infiltration. When the processes are very acute, the nuclei of the muscular fibres are destroyed together with the contractile substance and the sarcolemma; only on the stumps of the muscular filaments in the capsule of the abscess do we find the nuclei of the sarcolemma (muscular corpuscles) in considerable accumulations, and passing into the granulation tissue of the wall of the abscess; from these young muscular nuclei there proceeds, according to O. Weber, a considerable new formation of muscular fibre-cells (see fig. 24). The symptoms of muscular abscesses are not different from those of any other deep-seated abscess; their development and period of opening vary very much according to their size and extent. In many cases, when an abscess develops in the substance of a muscle, this latter contracts; this, for example, occurs in psoitis; whether this is the physiological result of the inflammatory irritation, or half voluntary and produced instinctively by the patients, I must leave for the present an open question, though I am rather inclined to the latter view, for in slightly painful, small abscesses of muscles, and also in traumatic inflammation of the same parts, there is usually no contraction, but this occurs only in larger abscesses which are exposed to the pressure of strong fasciæ. The abnormal positions of the limbs after the healing-up of muscular abscesses are due to the formation of cicatrices, and

their rigidity. Muscular abscesses should be opened as soon as the diagnosis is certain and distinct fluctuation can be felt.

A very peculiar form of disease of the muscles, which, in my opinion, is to be classed among the subacute inflammations, has been recently discovered and described by Zenker; it occurs principally during typhoid fever in the adductor muscles of the thigh; in this disease the contractile substance within the sheath of the sarcolemma crumbles up into separate fragments; these disappear gradually by absorption, while the old muscular cells are replaced by the formation of new ones. In this way, in the majority of cases recovery takes place; in other cases the diseased muscles remain permanently atrophied. We have no special observation as to whether this disease may lead to suppuration, although muscular abscesses, for instance in the abdominal walls, have been observed after typhoid fever.

5. *Acute Inflammation of the Sheaths of Tendons and Subcutaneous Mucous Bursæ (Serous Membranes).*

The sheaths of tendons form, as is well known, closed serous sacs, which are placed round some of the tendons of the hand and foot. They may become acutely inflamed by contusion, rarely also spontaneously. Like all acutely inflamed serous membranes, these sacs exude first a quantity of serum rich in fibrine; the newly formed fibrinous pseudo-membranes, composed in great part of wandering cells, may again dissolve, but may also induce temporary or permanent adhesions of the sheaths to the tendons; lastly, suppuration of the membranes not unfrequently occurs, and the tendon may thus become necrosed. Pain on movement and slight swelling are the first signs of such inflammation; occasionally there is also a friction sound, a creaking in the sheath of the tendon, which may be perceived by applying the hand, but still more distinctly by the ear. This sound is caused by the surfaces of the sheath and the tendons having become rough from fibrinous deposit and rubbing against each other whenever these tendons are moved; this subacute inflammation of the sheaths of the tendons is most common about the wrist-joint, and almost always terminates in resolution (tendovaginitis crepitans). Very acute inflammations of the sheaths of the tendons, arising from unknown causes and termi-

nating in suppuration, are of rare occurrence; they commence like an acute phlegmon, the subcutaneous cellular tissue rapidly participates in the inflammatory process, the limb is much swollen, and the neighbouring joints of the fingers, or the wrist-joint, may become involved in the inflammation. Like the synovial membrane of the joints, that of the tendinous sheaths appears, when acutely inflamed, sometimes to yield products that infect the parts around in a peculiarly intense way. If, under suitable treatment, suppuration does not take place, or, at least, does not appear externally, the absorption of the products of inflammation, the termination in resolution, is a very tedious process; the limb remains stiff for a long time, the adhesions formed between the tendons and their sheaths do not break down till after some months of use. If extensive suppuration of the tendinous sheaths occurs, which, in the fingers, has been termed "panaritium tendinosum," the affected tendons generally become necrosed, and may after some time be drawn out of the openings of the abscess as white threads and fragments; the membrane of the tendinous sheath then degenerates and forms spongy granulations. If the process be now arrested, one or more fingers are stiff and immovable, and remain so for life. If the joints be also attacked, there may in the fingers be recovery with anchylosis; but if the wrist- or the ankle-joint be involved, life may be placed in jeopardy by the continuous increase in the depth and extent of the suppuration, the retention of the pus, and its decomposition. It may sometimes happen that amputation of the affected limb affords the only chance of saving life. In acute suppurative inflammation of the tendinous sheaths, the fever at the outset is sometimes inconsiderable, but in severe cases the disease may commence with shivering. The greater the extent of inflammation and suppuration, the less tendency shown by the process to the formation of a circumscribed abscess, the more persistent is the fever and the more decidedly remittent does its character become; by this the patients are rapidly prostrated, the strongest men fall away to skeletons in a few weeks. The prognosis is very bad when the fever continues with intermittent attacks and shiverings.

The treatment of subacute crepitating inflammation of the tendinous sheaths on the back of the hand consists in keeping the hand at rest upon a splint, and painting over the diseased spot with tincture of iodine; if this does not afford speedy relief, a blister may then be applied. Under this treatment I have always

seen this form of inflammation of the tendinous sheaths disappear in a few days. If the symptoms are severe from the commencement, it is especially necessary that the hand should be kept at rest; to this must be added the application of mercurial ointment and several bladders of ice. This treatment should be continuously pursued for one or two weeks; subsequently, we employ moist, warm applications, and tepid hand-baths. If abscess form, incisions should be made and numerous counter-openings established. In these cases drainage-tubes are very suitable, because the granulations projecting from the openings very frequently impede the escape of the pus. Elevating the part considerably and even vertical suspension are, according to my experience, of no benefit in these deep-seated phlegmonous processes. If the suppuration will not stop, if the spongy swelling of the limb remains, if crepitation appears in the joints between the bones of the wrist (a sign that the cartilaginous coverings of these bones have suppurated), and if the patient sinks lower and lower, there is little hope of a favorable termination with anchylosis of the wrist, and the danger to life is so great that amputation must be performed. If this is done at the right time the patient may escape with his life, and will soon recover his strength.

The acute inflammations of the subcutaneous mucous bursæ are less dangerous; the bursa in front of the patella and that at the back of the elbow-joint are most frequently affected, either from injury or spontaneously; they are connected neither with the joint nor with the sheaths of the tendons; they become painful and filled with serum containing fibrine, the skin reddens, and the cellular tissue around the bursa participates in the inflammation; suppuration, however, never occurs if the patient is treated early. The treatment consists in applying mercurial ointment or tincture of iodine, placing the limb in a fixed position, and compressing the swollen bursa by applying a moderately tight, moist bandage. Puncture is generally unnecessary. In rare, unfavorable cases, this process gives rise to phlegmon of the whole lower extremity, which may even prove fatal.

LECTURE XXII.

CHAPTER XI.

ACUTE INFLAMMATIONS OF THE BONES, PERIOSTEUM, AND JOINTS.

Anatomy.—Acute periostitis and osteo-myelitis of the long bones: symptoms, terminations in resolution, suppuration, necrosis; prognosis, treatment.—Acute ostitis in spongy bones; multiple acute osteo-myelitis.—Acute inflammations of the joints.—Hydrops acutus: symptoms, treatment.—Acute suppurative inflammations of joints: symptoms, course, treatment, anatomy.—Acute articular rheumatism.—Arthritis.—Metastatic inflammations of the joints (gonorrhœal, pyæmic, puerperal).—Appendix to Chapters I to XI.—Retrospect.—General remarks on acute inflammation.

THE periosteum and the bones are in such intimate physiological relationship to each other that disease of the one tissue almost always involves disease of the other; and although in spite of this we are, for practical reasons, compelled to consider separately, at least to some extent, the chronic inflammations of the periosteum and the bones, yet we shall often be obliged to refer to their connection. I must here premise a few anatomical remarks, as they are of importance for the comprehension of the following processes. When speaking briefly of the periosteum, we usually mean by it simply the membrane which, poorly supplied with vessels, white, thin, and glistening like a tendon, is the immediate covering of the bones; but I must remark that this represents only a portion of the periosteum, which is relatively of little account in a pathological point of view. Upon this just-described inner layer of the complete periosteum, at points where no tendons or ligaments are inserted, there is a layer of loose cellular tissue, which is likewise to be

considered as periosteum, and which contains principally the ramifications of the vessels that enter the bone. This external layer of the periosteum is the most frequent seat of primary inflammations, both acute and chronic; the cellular tissue of which it consists is very loose and very well supplied with vessels, and hence more adapted for the development and spread of inflammatory processes than the dense, tendinous portion of the periosteum, poorly supplied with vessels, which is in immediate contact with the bone. As regards the nutrient vessels, especially of the long bones, the epiphyses have their own proper supply of them, which, as long as the cartilage of the epiphyses remains, do not communicate in the bones themselves with the branches of the nutrient artery of the diaphysis. This distribution of the vessels explains why inflammations of the diaphysis in young people rarely extend to the epiphysis, and *vice versâ*. Considered as to its origin, the capsule of the joint is a continuation of the periosteum, and a certain connection is frequently to be noticed between the diseases of the joints and those of the periosteum, inasmuch as the diseases of the one tissue readily extend to the other. We shall have many an occasion in the course of the following observations to return to these anatomical relations.

In the first place let us speak of acute periostitis and osteomyelitis (from ὀστέον, a bone, and μυελός, marrow), of which you have already heard something in the account given of suppuration of bone in the chapter on open fractures (see page 285). This disease is, on the whole, not very frequent; it occurs particularly in young individuals, and, in its most marked form, almost exclusively in the long bones. The thigh-bone is most frequently attacked, next the tibia, more rarely the bones of the arm and forearm. I have known the disease to occur as a primary affection after severe cold, or as a secondary one in the neighbourhood of acutely inflamed joints, and also after severe contusions and concussions of bones. It is possible that acute osteo-myelitis, like acute rheumatism and many phlegmons, may occasionally result from unknown general infection. Roser and Lücke are of this opinion.

In many cases we are unable to discover whether the periosteum or the medulla alone is involved; such a distinction is usually only rendered certain by the subsequent course and termination of the disease. The symptoms which present themselves are as follows. The disease begins with violent fever, not unfrequently with

shivering; severe pains are felt in the affected limb, which becomes swollen, without redness of the skin at the commencement. On account of the violent pain, the patient is unable to move the affected limb; every touch, every slight jar causes excessive pain; the skin is tense, usually œdematous, and sometimes the much distended subcutaneous veins gleam through, a sign that the reflux of the venous blood in the deep parts goes on with difficulty. The inflammation affects either the whole of the bone, or only a portion thereof. The existence, however, of an intense, deep-seated acute inflammation is all that we are able at once to diagnosticate from symptoms such as these. But inasmuch as idiopathic inflammation of the cellular tissue around the muscles and tendons is very rare, and is not accompanied with such severe pain, we shall not make a mistake in the majority of cases if, when meeting with symptoms as above described, we conclude that there is acute periostitis, possibly combined with osteo-myelitis. If with an equal amount of pain, and equally violent febrile symptoms, or complete inability to use the limb in consequence of the pain, the swelling fails to appear until several days have elapsed, we should be justified in concluding that the primary seat of the inflammation was in the medullary cavity of the bone, and that the periosteum at the outset was but slightly involved. In this stage, the condition of the affected parts may be conceived to be as follows. The vessels of the medulla and of the periosteum are greatly dilated and distended with blood; there may possibly be stasis of the blood at different points. The usual bright yellowish colour of the medulla is changed into a dark bluish-red, and the tissue is traversed by extravasations; the periosteum is greatly infiltrated with serous fluid, and, at the same time, on microscopical investigation it is found to contain a large number of young cells, as is also the medulla; there is, therefore, plastic infiltration. In this stage a complete return to the normal state is possible, and this is not so rare, especially in cases running a more subacute course, particularly if treatment is adopted early. The fever subsides, the swelling diminishes, the pains cease; a fortnight after the commencement of the disease the patient may have recovered. Even if the process is still somewhat further advanced, it may be arrested; in that case, a portion of the inflammatory new formation on the surface of the bone becomes ossified, and thus, for a time at least, there is a thickening of the affected bone, which subsequently disappears in the course of a few months.

In the majority of cases the course of the periostitis is not so favorable, but the disease advances, and terminates in suppuration. The external symptoms are then as follows. The integument of the much swollen, tense and painful limb assumes first a reddish, and then almost a brown-red colour; the œdema becomes more and more extensive, the joints in the vicinity become painful and swollen, the fever continues at the same height, and not unfrequently the attacks of shivering repeatedly recur. The patient is much exhausted, for he eats scarcely anything and is kept awake at night by the pain. Profuse diarrhœa not unfrequently sets in, the fever remains at the same point, the mind wanders, and the patient occasionally looks like one suffering from typhoid. Towards the twelfth or fourteenth day of the disease, seldom much earlier, but often later, we may feel distinct fluctuation, and can then greatly relieve the condition of the patient by making one or more openings for the escape of the pus, supposing that the skin over the abscess is already sufficiently thin; for the opening of deeper, stiff-walled abscesses which do not collapse is an operation which may prove dangerous eventually from decomposition of blood and pus in the not as yet sufficiently incapsulated abscess. The spontaneous perforation, particularly the suppuration of the fasciæ, sometimes takes a very long time, and, generally speaking, the openings thus formed are too small; operative assistance is therefore generally indicated. If you introduce the finger through one of the artificially made openings into the cavity of the abscess, you come directly upon the bone, and, in very many cases, find it denuded of periosteum. The extent to which this denudation goes on depends upon the extent of the periostitis. It may affect the entire length of the diaphysis, and in these worst cases the symptoms are most severe. Perhaps, however, only a half, or a third of the periosteum is affected; moreover, the whole circumference of the bone is not necessarily attacked, but perhaps only the anterior, lateral, or posterior portion; the periostitis not unfrequently terminates at the point of insertion or origin of large muscles. In such cases of slighter extent all the symptoms will be much milder.

Even now there are two courses which the disease may take: possibly, after the evacuation of the pus, the soft parts may rapidly again become applied and adherent to the bone, like the walls of an acute abscess. I have seen this several times in periostitis of the femur, in two or three children of three years old. A small quantity

of pus escaped after the opening, but only for a short time; the opening soon quite closed, the swelling receded, and complete recovery ensued. Such a termination, however, according to my experience, takes place only in very young children. It much more frequently happens that the bone, deprived in great measure of its nutrient vessels in consequence of the suppuration of the periosteum, either partially or completely perishes, and thus the condition arises which we term necrosis (from νεκρός, dead) or mortification of bone. The extent of this necrosis will essentially depend upon the extent of the inflammation; the wholly or partially destroyed diaphysis of the long bone must be detached from the organism as a foreign body, just as we have seen to occur in mortification of the soft parts and in traumatic necrosis. For this, however, a long time is required; the process of the necrosis, the separation of the portion of dead bone, the sequestrum, and everything connected with it, is therefore always a chronic one; we shall have more to say on this subject hereafter. Before the inflammation passes into this chronic stage, the acute local symptoms continue for a long time after the first opening of the abscess. Complications of various kinds may supervene; as long as these patients are not free from fever they are always in danger.

We must now return to the medulla of the bone, which we left in the first stage of inflammation. Here also the inflammation may terminate in suppuration; if the osteo-myelitis be diffuse or total, the entire medulla may suppurate. This suppuration may even assume a putrid character, and septicæmia may thence become developed. If there be extensive suppurative osteo-myelitis with suppurative periostitis, death of the diaphysis of the bone is certain to occur. Should there be only a partial suppuration of the medulla, or should this not occur at all, the circulation of blood in the bone may be in great measure preserved and the bone may retain its vitality. It may often occur that, under such circumstances, the bone for some time struggles in a manner between life and death, as the feeble circulation nourishes, though in a very imperfect degree, the tissue of the bone until the collateral circulation is sufficiently developed. An acute suppurative osteo-myelitis can scarcely occur without involving the periosteum; with the osteo-myelitis it not unfrequently happens that osteo-phlebitis (φλέψ, a vein) is combined; this may go on with putrefaction or suppurative dissolution of the thrombus, and, according to experience, is particularly prone to

induce metastatic abscesses. Another, not unfrequent, though by no means constant accompaniment of osteo-myelitis, is suppuration of the cartilage of the epiphyses in individuals in whom they still exist, that is, till about the twenty-fourth year. The process is not difficult to explain; the inflammation may extend to the cartilage of the epiphyses, partly from the medulla, partly from the periosteum; if the cartilage becomes softened, the continuity of the bone is thereby destroyed, and there is a certain amount of mobility as in a fracture at the seat of the epiphysis; dislocations may also be caused by contractions of the muscles. Usually, there is only one such separation of an epiphysis of the affected bone, either the upper or lower one; in more rare cases, the separation is double. I have seen one case of double separation of the epiphyses in the tibia, several cases of separation at the lower end of the femur, one of the upper end of this bone, one of the upper and two of the lower end of the humerus. In one case, I saw a softening of the epiphysis with displacement, resembling luxation, of the upper end of the femur without suppuration. We have already remarked that inflammations of the neighbouring joints are prone to accompany periostitis. Such inflammations run, as a general rule, rather a subacute course. The serous fluid, which accumulates in the joint in moderate quantity, is usually absorbed as the acute disease in the bone subsides; but the joint very often remains swollen, and not unfrequently there is permanent stiffness. Several times also I have seen acute periostitis and osteo-myelitis of the femur supervene upon acute articular rheumatism of the knee. We must finally remark that osteo-myelitis may occur in several bones simultaneously.

We ought to mention, though a rare symptom, the development of gases in the diseased joints, in many cases even before the abscess is opened. This is also a very bad symptom, and indicates putrescence of the inflammatory products. The pus in and around bones affected with osteo-myelitis, as well as in the nearest joints, often contains micro-organisms, even if it is not decomposed; from this it may be concluded that these organisms do not by any means necessarily lead, by their development, to the decomposition of the pus.

The diagnosis in any given case, as to how far periosteum and bone are involved in the inflammation, cannot be made with any degree of certainty; it can only be decided by the extent of the subsequent necrosis, and even this is no accurate test, for the perios-

titis may terminate in suppuration, while the osteitis may end in resolution, or only lead to a little interstitial new growth in the bone. The inflammation may begin (1) in the loose cellular tissue of the periosteum; this suppurates. If the suppuration confine itself to this layer, we may pass the finger, after the abscess has been opened, directly down to the bone, but we shall find it covered with the granulating tendinous part of the periosteum; if the suppuration, however, extend to this last-named layer of the periosteum, as it not unfrequently does, the bone lies exposed, and the suppuration may then spread to it. In this manner osteo-myelitis accompanies periostitis. If any one is disposed to regard this loose cellular tissue other than as periosteum, and rather to look upon it as a part of the intermuscular connective tissue (a view which is not justifiable, because in this layer especially the vessels coming from the bone are chiefly found), then there is no such thing as acute periostitis, because the tendinous portion of the periosteum takes on primary inflammation just as rarely as the fasciæ and the tendons. (2) The inflammation may begin in the bone and thence spread into the periosteum and cellular tissue; osteo-myelitis being the primary, periostitis the secondary disease; pus is found not only in the bone but also on its surface, immediately below the tendinous layer of the periosteum. This latter is raised up by the pus so far as its elasticity will allow; it then perforates, and the pus gets into the connective tissue, where fresh suppuration is set up, and so it comes to the surface. In consequence of the high arterial pressure in the medullary canal Roser asserts that fluid medullary fat is forced out of the medullary cavities through the Haversian canals of the cortical substance, and that osteo-myelitis may be diagnosed if the pus from beneath the periosteum be found mixed with globules of fat. Roser also found in some cases a remarkable lengthening of the bone and a relaxation of the joints nearest to the osteo-myelitis. He attributes this to a too rapid growth of the ligaments and of the epiphysial cartilages during the inflammation.

As regards the prognosis in acute periostitis and osteo-myelitis, we must distinguish between the danger to life and the damage to limb. If the disease lead to partial or total necrosis of the bone it may last for months, or even years. An acute periostitis and osteomyelitis, especially if they affect the thigh and occur on the two sides, are always dangerous to life, on account of the possibility of pyæmia, and in children, on account of the profuse suppuration which

they give rise to, they are more dangerous proportionately to the length of time which the acute stage lasts, the extent to which they extend, and the size of the bone which is affected.

The results of treatment of this disease are the most satisfactory when the surgeon is called in very early; one of the most efficient remedies is painting the whole limb with a strong tincture of iodine. This is to be repeated until extensive vesication develops itself, The patient naturally must remain in bed; he scarcely need be told to do this in the generality of cases, for the pain will induce him to keep quiet. Since I have adopted this iodine treatment I have been so well satisfied with the results that I have almost entirely given up the use of other antiphlogistics, such as cupping, leeches, and mercurial inunctions. Determination to the intestinal canal by means of saline purgatives should aid the cure in this and all other acute inflammatory diseases; at least we are so advised by the older surgeons, and judging from the diarrhœa, which frequently comes on spontaneously, it would seem as though nature thereby indicated a way by which the poison may be eliminated.

The local application of ice at the very commencement of the disease is strongly recommended by some surgeons. If suppuration occur in spite of these means, and fluctuation be distinctly felt, then make several openings at spots where the skin is thinnest, and in such a manner that the pus can get out without the necessity of having to be squeezed out; then put in drainage-tubes, in order to favour a free discharge; the swelling now usually subsides very quickly; it is most favorable when the fever ceases early and the disease becomes chronic. If the fever persist, the suppuration continue profuse and the pain remain, then it is well to combat these conditions by frequently irrigating the abscesses with antiseptic solutions, and to endeavour to reduce the inflammatory processes by the application of ice-bags. I have also gained great advantage from the application of fenestrated plaster-of-Paris bandages, in some cases complicated with detachments of the epiphyses, in order to fix the joint during the daily application of the dressing. Some kind of fixation of the joint in such cases is absolutely necessary. Many surgeons differ from this plan, which is nevertheless founded on a series of favorable cases. Many advise, from the very commencement, large and deep incisions down to the bone, or at least free incisions as soon as suppuration commences. Such extensive wounds in patients with fever are bad; I am satis-

fied that under these circumstances such heroic treatment aggravates the condition and increases the predisposition to pyæmia. Still more erroneous is the view that in acute osteo-myelitis exarticulation must be at once undertaken, or that otherwise pyæmia is unavoidable. This is certainly quite inexact, and amputation is not indicated under these circumstances, firstly, because the diagnosis of osteo-myelitis at the onset is not by any means certain; the disease might be a simple acute periostitis. Secondly, because the prognosis in exarticulation of large joints, when they are performed on account of acute disease of the bones, is always very doubtful. For instance, I should only decide to amputate in the thigh for acute periostitis with osteo-myelitis of the tibia, if the suppuration were very excessive, and had spread to the knee-joint. Should this disease affect the femur, and run an unfavorable course, I should scarcely expect to find the means of saving my patient in performing an operation so dangerous to life as is exarticulation at the hip-joint. By careful nursing we may accomplish much for these patients, as they are generally so young. A little girl with osteo-myelitis and periostitis of the tibia had sixteen rigors in twelve days, and recovered nevertheless, although a portion of the tibia necrosed and the ankle-joint became anchylosed.

I will now add a few remarks about suppurative periostitis of the third phalanx of the fingers, which is perhaps about the most frequent of all forms of periostitis. As inflammation in a hand and fingers is generally called panaritium, so this disease in the ultimate phalanx is called panaritium periostale.

The disease is very painful, like all periostitis in fact, for the pus is a long time, often eight or ten days, before it gets to the surface. The termination in either partial or complete necrosis of this little bone is common, and cannot be prevented even by an early incision, although we frequently find ourselves obliged to make one, in order partly by the loss of blood locally, and partly by incising the periosteum, to relieve the aching, throbbing, burning pain which accompanies the disease. As suppuration is almost invariably the termination, and can scarcely ever be avoided, we must endeavour to favour it by the application of cataplasms, hand-baths, and similar remedies, in order as much as possible to shorten its progress.

As yet we have only spoken of acute inflammation of the periosteum and medulla of the long bones, and have not considered therefore the inflammation of the spongy bones. Neither have we

considered the question of the inflammation of the bone substance itself. Is there such a thing as acute inflammation of the bone substance? If we set out with the view that dilatation of the vessels, cell and serous infiltration of the tissues in their varying quantitative combinations, constitute the essence of the inflammatory processes, we shall be compelled to deny that acute inflammation can take place in compact ossified bone, as these conditions are all impossible in the cortical substance of a long bone. The capillary vessels in the Haversian spaces are in many places so narrowly embedded that they cannot dilate very much; a moderate amount of serous infiltration of the bone substance is quite intelligible, though it is difficult to believe that firm bone substance possesses much power of swelling out. If the term inflammation be so generalised as to include any quantitative or qualitative disturbance of nutrition, we must then certainly allow that such disturbance may take place in bone, just as well as in the softer tissues. Every tissue which is attacked by inflammation changes its physical and chemical properties, and in the soft tissues this occurs very rapidly in acute inflammation. The connective tissue especially is quickly transformed into a gelatinous, albuminoid substance; the tissue of the cornea also and of cartilage may likewise change their characters in a relatively short time. For chemical reasons, this is not possible with bone substance; it requires time for the lime salts of the bone to be dissolved, and for the remaining animal matter to soften down like other tissues. Thus, the inflammation of the compact bone substance, however acute the process may be, cannot run a rapid course, it always requires a considerable time. What has been said, however, only refers to the compact substance; in a spongy bone, considered as an entire organ, acute inflammation is very possible, that is, an inflammation of the medulla contained in the spongy bones. The medulla here possesses the same qualities as in the long bones, except that it is not so heaped together, but is scattered about in the meshes of the bone; each mesh contains a large number of capillaries, also connective tissue, fat-cells, and nerves; acute inflammation of the spongy bones first occurs in these spaces, and thence gradually spreads to the bone tissue proper. What we usually speak of as acute ostitis of a spongy bone is at first only acute osteo-myelitis; inflammation of this kind occurring spontaneously is only very rarely acute; it is sometimes sub-acute, but generally chronic. On the contrary, there is an acute traumatic

osteo-myelitis of a spongy bone, about which we will make a few remarks, although we have already alluded to the most important points in the section on the suppuration of bones. Just imagine an amputation wound close below the knee; the tibia has been sawn through its upper spongy part. Traumatic inflammation sets in in the medulla, in the meshes of the bone substance, with proliferation of vessels, infiltration of cells, &c., and this will lead to the formation of granulations which grow out of the medulla, and soon form a continuous granulating surface; the cicatrization takes place in the usual manner. But somewhat later on, if you have the opportunity of examining such a stump, you will find at the sawed surface that the meshes of the bone are filled up with bone substance, and that the most external layer of spongy substance has been converted into compact tissue; the cicatrix in the bone has, in fact, ossified. This is the normal termination not only of traumatic but also of spontaneous ostitis: the cicatrix ossifies.

Suppuration and decomposition of the medulla of spongy bones may also occur; osteo-phlebitis too, with its consequences, may set in. In the chapter on the suppuration of bone and the healing of compound fractures we have fully discussed the changes which occur after a bone has been denuded of its periosteum, the development of granulations on the surface of the bone, and the superficial necrosis, which follows; I would again refer you to this chapter.

I will just mention further that there are cases of acute multiple inflammation of bone, similar to the acute multiple inflammation of joints (acute polyarticular rheumatism); thus, inflammation of both bones of the lower extremities may occur together, or one may follow the other; for instance, osteo-myelitis of the tibia, suppurative inflammation of the knee-joint, osteo-myelitis of the femur, suppurative inflammation of the hip-joint; in one case there was also osteo-myelitis of the other femur and suppurative osteitis of the other side. Even these cases may possibly run a favorable course, though it is extremely rare—they are generally fatal.

The statement which I have made, that I am unable to imagine an acute inflammation of bony tissue, has led to much misconception. But certainly no changes in fully formed (adult) bone tissue are appreciable even in acute inflammation of bones, though changes in the medulla and its vessels and in the periosteum and its vessels can be recognised. I do not at all underrate the chemical changes

(disturbance of nutrition) which take place during inflammation; yet we are not well acquainted with them, we only recognise them through the changes which take place in the tissues we see. We see that inflamed tissue swells up, we see that it becomes soddened, we see that it is infiltrated with wandering cells, we see that it softens, and finally that it breaks down into pus, we see that all this often takes place in a few days. In bone-tissue we see nothing of such changes; in acute inflammation we see no swelling out, we do not see its alveoli (with the exception of the Haversian canals) or canals filled up with wandering cells, and we know also that it does not undergo suppurative softening. We are only acquainted with one termination of acute ostitis—death, necrosis; besides this the acute may assume a chronic form. Thus we can only say it is probable that disturbances in the nutrition of bone tissue take place during acute inflammation of bone tissue, exactly as in acute inflammation of the other connective tissues, but that there is no appropriate morphological word to express it, and that owing to the peculiar nature of bone tissue there cannot be a word to express it.

We now come to acute inflammation of joints. As we have previously spoken of traumatic inflammation of joints, you already will be acquainted with many of the peculiarities of diseased joints. We already know that serous membranes when irritated are very prone to pour out fluid exudations, and in addition to this that the serous exudation may contain pus if the inflammatory irritation is very intense. Just as there is pleurisy with sero-fibrinous exudation (the ordinary form) and pleurisy with purulent exudation (so-called empyema), so also do we speak of serous effusion or hydrops and of purulent synovitis (empyema); either of these forms may be acute or chronic, and lead to various diseases of the cartilage, of the bone, of the ligaments of the joint, of the periosteum, or of the surrounding muscles. You will see that the more intricate a diseased part is, the more complicated will be the diseased process. In recent times great importance has been attached (especially by French surgeons) to the subdivision of diseases, according to their anatomical conditions, into disease of synovial membrane, disease of the articular cartilages, then of the ligaments, and last of the bones. However correct this division would be if it were only a question of pathologico-anatomical changes, it is an altogether useless way of treating the subject for practical purposes.

The surgeon always looks upon disease of a joint as a whole, and although he must know whether this or that structure is the more affected, yet this is only one part of what he will be expected to know and to do; the course of the disease, the order of symptoms, the general condition of the patient, will each in its turn demand his attention, and modify his therapeutic treatment. Hence the entire clinical picture can alone determine the classification of this, as of many other diseases.

At present we are speaking only of those acute inflammations which appear to come on spontaneously. In many cases they evidently arise from a severe cold; in other cases their cause is not known. Some of the more subacute cases are metastatic in their nature, and come on in connection with other pyæmic symptoms. At present, however, we are not engaged with this class, but rather with those cases of inflammation which appear to have resulted idiopathically, and which, in contradistinction to the traumatic cases, one hears spoken of also as rheumatic, owing to their supposed origin in cold. The patients, who call you in for these acute inflammations of the joints will present various symptoms. If, for the sake of illustration, we confine ourselves to the knee-joint, the following will be about the condition:—A strong, apparently otherwise healthy man takes to his bed because his knee-joint has been stiff for the past day or two; it is swollen and painful. On examination you find that there is distinct fluctuation within the joint, that the patella is somewhat raised, and that it springs up again after it has been pressed down; the skin over the knee is not reddened; the patient lies in bed with his leg extended, and is free, or almost free, from fever, and when asked can, though with a little difficulty, bend and straighten the limb; the whole examination is not painful. You have here an acute serous synovitis—hydrops genu acutus. The anatomical condition of the knee is as follows:—The synovial membrane is slightly swollen and moderately vascular, the cavity of the joint is filled with serum, which has mingled with the synovia; in the fluid also there are a few fibrinous flocculi; all the other parts of the joint are healthy. Anatomically, the condition is just the same as in acute bursitis tendinum, or in a moderate pleurisy. This disease of the joints is generally easy to cure: rest, repeated painting with iodine, or a few blisters, or even compression with a wet bandage, will suffice to cure the condition in a few days, or, at least, to

moderate its acuteness; for it may happen that all the acute symptoms pass away, and that the patient may get about again without any difficulty, even while a considerable quantity of fluid remains in this joint, a hydrops chronicus being left behind; of this we shall speak presently.

You may be called to another patient with inflammation of the knee-joint. A few days previously the young man caught a violent cold, and shortly afterwards experienced severe pain in his knee, became feverish, perhaps had a severe rigor, the joint becomes more and more painful. The patient lies in bed with his leg flexed, and with the thigh strongly rotated outwards and abducted; he resists every attempt to alter the position of the limb, because it causes such severe pain. The knee-joint is greatly swollen, it feels hot when touched, but there is no definite sense of fluctuation; the skin is slightly œdematous, and over the knee it is gently reddened; the leg also is swollen and œdematous, and it is impossible without intense pain to further flex the joint. What a different picture from the last! If you chance to examine the interior of the joint during this stage, you will find that the synovial membrane is greatly swollen; it is intensely injected and puffy, and if you examine with the microscope you will find it infiltrated with plastic and serous material. In the joint cavity there is generally a little flocculent pus mixed with synovia, or there may be a little pure pus. The surface of the cartilage looks a little dulled, but scarcely shows any microscopical changes besides cloudiness of its hyaline substance; perhaps, also, the cavities of the matrix are a little dilated, and the contained cells somewhat less distinct than in the normal condition. The ligaments of the joints are also œdematous. Here you have to deal with a parenchymatous, suppurative, very acute synovitis, in which the cartilage threatens to participate. If the condition last somewhat longer, and the quantity of pus within the joint increase, you may then correctly speak of it as empyæma of the joint.

The difference between the first and the second form of acute synovitis consists chiefly in this fact, that in the second case the substance of the synovial membrane was deeply affected, while in the first the increase of the synovial secretion was the chief feature. Between these two extremes, however, there are cases which run a subacute course, in which the secretion becomes purulent and collects within the joint in large quantities without

leading on to any very deep destruction of the synovial membrane. R. Volkmann calls this "catarrhal inflammation of a joint." There is a little more pain than in cases of simple acute hydrops, from which the purulent catarrhal form may also arise, though it is a very unusual occurrence. Concerning the course and treatment of acute hydrops, I have already said all that is necessary. As regards the further course and the treatment of the more parenchymatous forms, which are disposed to suppurate, much will depend on when the treatment is begun and in what it consists. Generally a few leeches are applied to the joints, and then it is poulticed, in the old belief that rheumatic inflammations of joints must be treated by warmth. As to the leeches, I consider them entirely useless in this affection; as to the value of warmth there is, perhaps, still room for discussion, because warmth is generally very acceptable to the patient, and very often affords greater relief to the pain of inflamed serous membranes than does the application of cold; at least, the latter certainly requires a longer time to produce favorable results. I explain this circumstance as follows:—The warmth produces a determination of blood to the cutaneous vessels, and thus tends more or less to empty the vessels of the synovial membrane towards the exterior; this action, however, cannot be long sustained, and the blood will again rush to the inflamed synovial membrane, perhaps even more vigorously than to the artificially heated skin. On the other hand, the application of a large ice-bag causes the contraction of the cutaneous vessels, and possibly, just at first, causes a stronger current of blood to flow towards the deeply-lying, inflamed parts within the joint; but gradually the cold begins to act on these also, and its contracting influence then continues as long as the ice is persevered with. It seems very rational always to employ cold in these cases, and in actual practice the employment of ice-bags for the treatment of acute inflammation of joints has proved itself exceedingly useful. In addition to the cold, you can obtain active counter-irritation by the application of strong iodine, or you may apply a large blister. Besides these means, and even before you commence their use, it is of the greatest importance to get the joint into a good position, and there to fix it; for if this cannot be done, we shall not be able to obtain a complete *restitutio ad integrum;* the joint will be stiff, but it will be flexed also—a very undesirable addition to its immobility, for under such circumstances, the leg would be of little further use. It is a very

difficult question to decide why an acutely inflamed joint, especially one undergoing acute suppurative inflammation, should almost always involuntarily assume the flexed position; it has been explained in various ways. It is believed by some, in consequence of the strong irritation of the sensory nerves of the synovial membrane caused by the inflammation of the joint, that a kind of reflex spasm in the motor nerves leads to contraction of the flexor muscles. Bonnet, a French surgeon, who has rendered great service in this department of surgery, believed that in great distension of a joint with pus, or in swelling of the synovial membrane, the joint would mechanically assume the flexed position, simply because its cavity was more capacious during flexion than during extension. He endeavoured to prove this experimentally; he injected fluids into the joints of the dead, and brought the limbs into a condition of flexion by forcibly distending the joints with fluid. Against this may be said, in hydrops acutus, where there is usually much more fluid in the joint than in suppurative synovitis, that flexion does not occur, and further that in cases of acute inflammation of a joint, where I have myself verified the total absence of fluid, there has been flexion notwithstanding. I am strongly of opinion that the acutely swollen, painful condition of the synovial membrane is the chief cause of the flexed position; hence I should be inclined to explain the circumstance by regarding the pain as the irritation in consequence of which the muscles of the extremity contract; other muscles also contract when situated near a painful part; for instance, the muscles of the neck in case of deeply-seated abscesses of that part. This mal-position must be overcome, and it must be done in such a way that, if permanent anchylosis of the joint take place, the limb shall be fixed in that position, which will allow of the greatest amount of utility afterwards. Thus, for the hip- and knee-joints you will make extension; the ankle-joint must be placed at right angles, as also the elbow-joint; the wrist- and shoulder-joints rarely get into bad position, for the former generally remains extended, while the latter places itself so as to rest on the chest-wall.

I will here just remark, that there is a very great difference in the relative frequency of disease in different joints. Thus the knee-joint is most frequently affected, next in order come the elbow and the wrist; acute inflammation of the hip-, shoulder-, and ankle-joints, is rare. These acute inflammations occur more frequently in young than in old people: they rarely occur in children. Let us

now return to the subject of position of joints. You will perhaps remind me that to accomplish this is very painful. Chloroform is a great help, and indeed in the treatment of joint disease it is of the very greatest importance. Freely anæsthetise your patient, and then you will be able to move the joint without any trouble; for muscles which on the slightest touch of the leg firmly contracted now yield without any resistance. To continue with our hypothetical case, you will extend the knee, surround it with a thick layer of cotton wool, and apply a plaster-of-paris bandage from the tip of the toes up to the middle of the thigh. When the patient wakes up from the chloroform, he will probably just at first complain of great pain. You must give him a little morphia, and apply one or two large ice bags over the plaster of paris to the knee: the cold will slowly find its way through to the joint, and within twenty-four hours the patient will feel tolerably comfortable in his new position. The gentle compression which is exercised by the well padded plaster-of-paris bandage also acts antiphlogistically. If the fever continue you can give febrifuges internally, but otherwise no further treatment is required. Before applying the bandage you can have the limb well rubbed with mercurial ointment or painted with iodine. It is indeed our duty to apply this dressing even during the most acute state, naturally using the greatest precautions, and carefully avoiding too tight constriction. In recent times, and even in very acute mischief, the modern treatment by extension and a weight has produced some marvellous results; and indeed it is most interesting to observe how the pain in a joint may be lessened and the muscles straightened by a continuous and uniform extension. But in these cases very much depends on the manner of applying this principle of extension, and I cannot sufficiently recommend you the importance of close attention to this apparently simple subject; a subject the great importance of which you will only perhaps learn to appreciate, when you are independently settled in practice, and must do everything, even to the smallest detail, for yourselves.

If you are called to the patient early, you will in some cases succeed by the application of this treatment not only to arrest the disease, but also to preserve a moveable joint for your patient. But even if only called in during a later stage the above treatment must still be adopted. When the pain is relieved, and when the fever has ceased, the bandage may be removed at the end of a few weeks;

for the disease, under any circumstances, is sure to last for several weeks; it may even last for from three to five months, before the inflammatory process quite ceases: the normal condition will gradually return, and the former movements become re-established; then you must very earnestly warn the patient about cold, and too violent movements, for the disease might not run such a favorable course if it were to occur again.

Let us take a case for illustration in which the acute inflammatory process does not subside under this treatment, but goes on progressing; it may either become chronic or continue acute: of the chronic form we will speak presently. For the present let us suppose that the pain has not subsided, but rather has become more intense, and you are therefore obliged to slip up the bandage along the front. You will find the knee more swollen, very definite fluctuation, and the patella floating; the patient is intensely feverish. If allowed to go on, the fluctuation may happen to spread further and further, and the subcutaneous tissue of both thigh and leg may become implicated in the suppurative inflammation. Formerly the cause of this extension was generally supposed to be the subcutaneous bursting or partial suppuration of the synovial membranes connected with the joint, especially of the large synovial sac beneath the quadriceps extensor, and of the bursa poplitea; in order to anticipate this very untoward accident, it used to be considered proper at this stage of the disease to almost evacuate the joint with a trocar and canula, and then very carefully close the wound. As the result of my own experience, I should say that this mode of procedure is but very rarely indicated, for I have convinced myself by careful clinical observation, and also as opportunity afforded by observation on the dead subject, that peri-articular abscesses in the connective tissue, which occur in acute synovitis and also in the inflammation of the extremities of bones forming joints, occur independently, and break into the joint later on, if they do so at all. The general condition of the patient gradually gets worse during the development of these abscesses: it shows itself in heightened fever with repeated rigors, pinching in of the features, emaciation, complete loss of appetite, and of sleep. Quinine and opium finally lose their effect, and the patient sinks from the exhausting suppuration, the continuous fever, and perhaps also the supervention of metastatic abscesses, unless you cut short the local mischief by timely amputation through the thigh. If, by means of

ice, punctures or incisions in order to let out the pus, and quinine and opium, you succeed in arresting the acuteness of the disease, and in making it chronic, though you will not obtain a moveable joint, you will nevertheless get a useful limb, even if it is anchylosed at a right angle: this is the most satisfactory result which, after many days and weeks of anxiety and care, we can possibly expect for our patients, when the inflammatory changes go on to the degree we have described. The pathological changes which we find in a knee-joint in this stage of inflammation are as follows: the joint is filled with thick, yellow pus, mixed with fibrinous flocculi; the synovial membrane is covered with thick fibro-purulent deposits, beneath which it is reddened, swollen, and in parts ulcerated, the cartilage is partially softened, partially necrotic, and may be peeled off in larger or smaller pieces: the bone beneath it is highly reddened, and probably infiltrated with pus (osteo-myelitis, in this class of cases more frequently a secondary than a primary disease).

The prognosis in this disease is not very bad in young vigorous subjects, if appropriate treatment be early resorted to; it is very bad, if not absolutely fatal, in old decrepid individuals.

In the above description I have pictured to you typical cases of the two forms of synovitis, the serous and the parenchymatous (purulent), and I feel satisfied that in practice you will easily recognise either of the forms; and you will have no difficulty in applying what I have said of the knee to other joints.

I must now add that there is yet another acute or subacute form of inflammation of the joints which presents many peculiarities. I refer to acute articular rheumatism. This very peculiar disease, which will be more thoroughly treated of in your lectures on medicine, is characterised by its generally attacking several joints at one time, and by a predisposition to cause inflammation of other serous membranes, pericardium, endocardium, pleura, occasionally the peritoneum, and the arachnoid. The simultaneous affection of these membranes and of the joints characterises this disease as one which involves the whole body at once. Indeed, on account of the importance of the organ, pericarditis and endocarditis come prominently to the foreground, and influence strongly the whole treatment, so that the surgical treatment of the joint becomes quite of secondary importance; this is all the more likely to occur because the joint

disease, although exceedingly painful, seldom proves dangerous either to life or limb. Great pain in the joint on any attempt at movement or on pressure, œdema of the soft parts around, in some rare cases redness of the skin, are the chief symptoms of the local mischief, beyond which the disease rarely goes. From the few *post-mortem* examinations which we posses, it appears that the synovia is somewhat increased in quantity, and is occasionally mixed with pus-flocculi; the synovial membrane is swollen and reddened, the cartilage is rarely affected, and the amount of fluid is seldom sufficient to give fluctuation. Acute rheumatism is very common, but it is rarely fatal, and so the pathological anatomy is not extensive. According to all the evidence which the disease affords, it is clear that it is specific disease, *sui generis*, the course of which, however, is so atypical, its causes so little understood, that its actual nature has not yet been determined on. It appears to be doubtful whether, in addition to this polyarticular rheumatism, we ought to speak of non-articular rheumatism, for it is just this multiplicity of the inflammatory foci, and their slight tendency to suppurate, which characterise the disease; at any rate, I should hesitate to describe an inflammation confined to one joint as a part symptom of acute rheumatism until either pleurisy, or pericarditis, or some other complication peculiar to rheumatism had shown itself. If none of these should come on, then we have to deal with a purely local process, a simple articular inflammation, which we, perhaps, call rheumatic, simply because it seems to have resulted from cold. As regards the course of the inflammation of joints in acute rheumatism, the termination by resolution and complete recovery of the joint as to its functions is so usual, that we scarcely ever hear of any other. That the disease is tedious, and generally lasts six or eight weeks, is due less to the length of time during which any one joint is affected than to the fact that first one joint and then another is attacked, and also to the great frequency with which relapses may take place in joints, which seemed to have quite recovered. Thus the disease becomes very tedious both for patient and doctor, and consequently the greatest watchfulness and care are required to avoid any influence, which might tend to bring on the disease afresh.

It is extremely rare for any one joint to assume active suppuration, to go on to empyema; we oftener see that a joint, in spite of the termination of the disease, remains painful and stiff; in fact, the disease assumes a chronic form. You see that the prognosis

of this disease, as far as the joint goes, is relatively favorable; the disease generally runs a favorable course even without the help of the surgeon. All that we can do for the local disease is to protect the affected parts from variations of temperature by enveloping them in wool, tow, or oakum. Mild external counter-irritation, painting with iodine, may be supplemented. To alleviate the pain in the joint, and to hasten the course of the disease, Stromeyer and others have recommended the application of ice, and generally cool rather than warm surroundings. I scarcely imagine that this treatment will find many supporters, because it is troublesome to procure and apply the ice, and because experience shows us that this kind of inflammation runs so favorable a course without it. Internally you must order diuretics, diaphoretics, or cooling salts; where there is heart affection, local antiphlogistics, digitalis, &c., are indicated, as you will be taught in your lectures on special pathology and in the medical wards.

Similar to acute rheumatism is an acute attack of arthritic inflammation of joints. An attack of podagra or chiragra is equally specific, and is allied to true gout; the inflammation here, too, is an acute serous synovitis, but with an extremely small amount of effusion into the joint. But that which is most peculiar in arthritic inflammation is the almost constant and simultaneous inflammation of the surrounding parts of a joint, of the periosteum, of the sheaths of the tendons, and especially of the skin; the latter always becomes reddened and shiny, and tense, as in erysipelas, and it is intensely tender; it occasionally desquamates after the attack; acute arthritis is much more painful than the synovitis of acute rheumatism.

We will speak of the treatment of arthritis and of the arthritic diathesis later on.

We have yet to mention one other variety of acute joint inflammation, viz. the metastatic, about the causation of which we shall have to speak under pyæmia. Acute or subacute metastatic inflammation of joints, at first, is usually serous, but soon becomes a purely suppurative synovitis. Several varieties may be distinguished.

1. *Gonorrhœal inflammation of joints.*—This occurs in men suffering from gonorrhœa; it may also be produced by the too frequent passing of bougies into the urethra; it almost invariably attacks the knee. It is taught by many authors that this synovitis

is particularly liable to occur when a gonorrhœa has been suddenly stopped; as the result of my own experience I am unable to accept this view; the disease is exceedingly rare in proportion to the enormous amount of gonorrhœa which occurs. I have seen it several times occurring during an active gonorrhœa as the result of catching cold. One might almost feel disposed to deny any connection between purulent catarrh of the urethra and inflammation of the knee-joints, and ascribe their simultaneous occurrence to pure accident; but it is in the experience of too many surgeons for it to be accidental, and further, the cases in which it occurs as the result of irritation in the urethra from other causes, *e.g.* catheters, strongly speaks in favour of it. Gonorrhœal gonitis generally occurs on both sides; it is a subacute serous synovitis, which generally terminates in complete recovery of the joint provided the patient will keep at rest, and avoid all further irritation of the urethra; you must apply blisters, iodine, and gentle compression until all the fluid is absorbed. Nevertheless, a slight irritation of the joint frequently persists, and it is a matter of common observation that these individuals, on getting a fresh gonorrhœa, are very liable to another attack of the joint affection. Chronic articular rheumatism is said to result from gonorrhœal gonitis.

2. *Pyæmic inflammation of joints* also occurs in one or other knee-joint; in the ankle too, shoulder, elbow, or wrist—rarely in the hip-joint. It is a purulent synovitis in the most typical sense, and is associated in the later stages with destructive suppuration of the peri-articular connective tissue; it usually runs a subacute course, and thus it is rarely fully developed when our patients come to be examined *post mortem*. Pyæmic patients with inflammation of joints do not always die. I have occasionally seen absorption take place in the cases in which the patients had pulled through the general infection. The treatment is just the same as that already mentioned: in large collections of pus puncture will have good effect by relieving the pain. Joint diseases, whch are due to injuries, lacerations of the urethra from careless catheterisation, and which are mostly accompanied by rigors, obviously do not belong to the gonorrhœal, but rather to the pyæmic, variety. I had to treat a young man in Berlin who was suffering from laceration of the urethra as the result of catheterisation; an abscess afterwards formed on the left shoulder, with destruction of the acromio-clavicular joint, and

subluxation of the clavicle due to this cause. The patient recovered perfectly (as regards his urethra), and as the abscess was not large, I did not open it. I saw the young man one year afterwards, the abscess had become somewhat smaller; there was distinct fluctuation; seeing that this abscess did not produce any disturbance in the function of the joint, or indeed anywhere, that the patient was blooming and healthy, I decided not to open the abscess, and I advise you in similar cases of cold abscesses, which are known to communicate with a joint, to do the same, for little is gained by an opening, while much damage may be done: an acute inflammation of a joint may possibly result, with the dangerous consequences to which we have already referred.

3. *Puerperal inflammation of joints.*—Puerperal or malignant lying-in fever is a form of pyæmia which sometimes develops in the course of parturition. The purulent inflammation of joints which occurs at this time thus comes within the category just described of pyæmic suppurative synovitis.

During the third or even the fourth week after parturition an acute suppurative inflammation, especially of the knee or elbow-joint, comes on, which, as regards its mode of origin, is differently explained. Many believe that it is a simple form of acute joint inflammation, which results from catching cold; to this lying-in women are especially liable, because they perspire so much and so freely. Others believe that these late inflammations of the joints are single symptoms of pyæmia, which has otherwise been overlooked, in other words, regard them as metastatic. Be that as it may, it is nevertheless certain that the cases have nothing specific about them: sometimes they run an acute, sometimes a subacute course, and not unfrequently by appropriate treatment the disease may be so held in check that the joint may recover with motion. It does nevertheless happen that a more chronic course is assumed, which terminates in anchylosis.

On the whole the prognosis in these joint diseases is not so very bad; very seldom attains the highest degree of severity. Treatment is exactly the same as we have already described in acute purulent synovitis.

I will just mention that suppurative inflammation of joints occurs in the pyæmia of the newly born: children are even born with the disease occasionally, as has been observed by myself and others.

Inflammation of joints may occur during fœtal life; it may even run its course completely, as is proved by those cases in which children are born, fully developed, but with anchylosed joints.

APPENDIX TO CHAPTERS I—XI.

Retrospect. General remarks on acute inflammation.

GENTLEMEN,—I have thus far brought before you a variety of clinical surgical cases, by means of which the acute inflammatory process in its various forms was represented. We have passed in review injuries and their consequences, as also those acute inflammations, independent of injuries, which come within the province of surgery, and have studied the physiological processes which are hereby interfered with, the means by which they are compensated for, and the methods by which they are repaired. This plan of study seemed to me fitted for you, and indeed indicated, for I took for granted that you would already possess some knowledge of general pathology, and probably appreciate the pathological, physiological, and histological discussions, which any suitable opportunity might allow me to make. Nevertheless, it may not be out of place at the close of this the first and largest part of our task, if I give you a short *resumé* of the doctrine of inflammation as now held, which has recently been materially advanced by the labours of Cohnheim, Samuel, Arnold and others. I shall be very brief, and follow up on what I have already said.

I must begin with the remark that we must leave out of our consideration the nervous system, on account of our meagre knowledge of its influence on, and participation in, inflammation. The blood-vessels, the blood, and the tissues form almost exclusively the subjects of our study.

The dilatation of the blood-vessels is an important factor in inflammation, and yet neither the hyperæmia caused by the arrest of the blood in the veins (congestive hyperæmia), nor the dilatation of the arteries from paralysis of their coats (*e.g.* in the ear of a rabbit, after section of the cervical sympathetic), nor the sudden primary dilatation of vessels after mechanical or chemical irritation (primary

irritative congestion), necessarily and directly leads to inflammation. I have something to add to the last-mentioned variety of vascular dilatation. The matter stands thus : you rub the eye, for instance, and it becomes red; you rub the skin, it becomes red; you apply warm water to the skin, it becomes red; you apply snow to the skin, it first of all becomes pale and then red. All these appearances are exceedingly transitory, provided the causes which lead to them are only allowed to act for a short time, and are then removed. The experiments already referred to relate to the method of production of this hyperæmia : they are now considered insufficient. The symptom is fully appreciated by Cohnheim : yet if we attribute to heat and cold and to chemical agencies a direct, and for the moment paralysing, influence on the walls of the vessels, it is surprising, according to our present theories, that this paralysing influence should extend to an extensive tract of the surrounding tissues from a circumscribed area of pressure or irritation after the manner of concussion or of a wave-current. It seems to me that as yet we know nothing further of this "affluxus" from "stimulus." Cohnheim has shown, what is very important in this matter, that in cases where definite inflammation follows on mechanical or chemical action, the primary congestive hyperæmia may have long disappeared before the new and lasting hyperæmia, which leads to and accompanies the inflammation, makes its appearance; this primary congestion may even under certain circumstances be entirely absent in some cases, and the inflammation with its specific inflammatory hyperæmia may nevertheless ensue. From this it is clear that the congestive hyperæmia, which so immediately follows on an irritant, is not an absolutely necessary factor in inflammation.

A rabbit's ear, the vessels of which in consequence of section of the sympathetic are paralysed and dilated, does not necessarily inflame : its tissue in consequence of moderate œdema feels somewhat firmer, but it leads to no further change, nor to any trophic disturbance in either the vessels or the tissue.

Any extensive, congestive hyperæmia does no doubt lead to serious consequences. It has already been mentioned that an increase in the blood pressure, as it occurs after slight injuries, quickly passes off, and cannot be appreciated as a factor in inflammation. But if this congestion of blood extend over a very large area and cannot be compensated for, copious exudation of serum into the connective tissues (œdema) takes place, so copious that it

cannot be taken up by the (still) active lymph vessels; and at the same time there is an escape of red blood-cells through the walls of the capillary vessels into the tissue (diapedesis): Cohnheim had even at this time suggested that probably the diapedesis took place through preformed openings in the capillary vessels. Arnold had not only verified this, but had actually demonstrated that the so-called stigmata (*i.e.* minute orifices which after staining with nitrate of silver become visible between the cells composing the capillaries) are the points of exit, and he added that the serum of the blood streams out of these stigmata. If the arrest of the circulation is only partial, nothing further than œdema and diapedesis take place; if the circulation entirely cease, and the blood coagulate, gangrene results.

Finally, if we now come to the hyperæmia which accompanies inflammation, we see that it is neither the result of a temporary irritation, nor the consequence of a paralysis of the nervi vasorum, nor caused by arrest of circulation, but that it is the consequence of a peculiar alteration in the walls of the vessels (especially of capillaries and veins). We are unable to say what chemical or physical change takes place in the vessel wall: we only conclude that the vessels of the inflamed district are permanently dilated, and allow an enormous quantity of the white blood-cells (not only through the pre-formed stigmata, but also at every part of the vessel wall) to escape; in fact, that the substance of these vessels is in a softened and yielding condition. It is not very easy in all cases to determine why they should get into this condition: it is generally considered to be the direct effect, although only occurring after the lapse of some time, of the inflammatory process or the inflammatory irritation. On attempting an explanation of the presence of an extended (however slight this may be) inflammatory border or focus after sharply defined injuries by incision or puncture, the same difficulties again present themselves which were encountered in the explanation of primary congestion. We must somewhat unwillingly accept that an injury to the vessels can never be exactly confined to those vessels which seem to be directly affected, and that under any circumstances the injury spreads out a little; least of all in incised wounds, punctures, and circumscribed rapid burns, most so after certain chemical effects. This, however, is really no explanation at all, but simply a paraphrasing of the observation itself.

Let us now take into consideration the blood and the blood current in the inflamed tissues. The primary afflux is accompanied by a considerable increase in the rate of the blood-flow, especially through the arteries; this latter returns to its normal rate of flow if the primary dilatation of the vessels goes down. In the vessels which are permanently dilated in the district of the inflammatory focus the rate of the circulation gradually decreases, especially in the veins; then it becomes irregular, and occasionally completely arrested in places. This stasis, which is not necessarily associated with coagulation, was formerly looked upon as a very important part of true inflammation; it has been variously explained, but these explanations have now little interest for us, because we well know that many inflammations run their course without stasis, and that this stasis, in spite of progressive inflammation, again resolves; if it remain permanently, coagulation of the blood in the vessels takes place (thrombosis), with all its sequelæ, according to the local conditions and extent of the thrombosis. Either a *restitutio ad integrum* in the district of threatened tissue takes place by collateral dilatation, or gangrene sets in. In consequence of the slow and irregular circulation (which later on, however, again becomes normal) within the inflamed area, large numbers of white blood-cells gradually heap up around the walls of the small veins and capillaries, and become adherent; this is spoken of as adhesion of the white corpuscles to the vessel wall (*Randstellung der weissen Blutkörperchen*); the migration of these cells through the vessel wall into the tissue then begins, the interstitial filling of this tissue with the wandering cells (cellular, or if in very great quantity, purulent infiltration), eventually the migration of cells on to the surface (surface suppuration, purulent catarrh, secretion of pus).

We have now the complete picture of acute inflammation before us; but just as the process even at the stage of vascular dilatation and hugging of the arterial wall by the white blood-cells may subside, so may it subside even in later stages, when there has been rather extensive cellular infiltration, without leaving traces in the infiltrated part or in the dilated vessels of any visible change. If, however, the infiltration attain a certain intensity, the infiltrated tissue entirely disappears, and pus forms in its place, an abscess develops; or an interstitial new growth forms (granulation tissue, inflammatory new growth) which takes the place of the inflamed tissue, and which, unless it be destroyed by any subsequent necro-

biotic changes, becomes developed into connective tissue (scar), vessels and nerves.

Let us inquire how this disappearance of the inflamed tissue is brought about: is it caused by the direct action of the inflammatory agent, or is it due to the cellular infiltration? This brings us to the third important point in inflammation, namely, the behaviour of the tissue itself during the changes which we have just described. Let us first of all consider the inflammations produced by well-known chemical and physical agents: there can be no doubt that they cannot possibly act on the vessels and on the blood without at the same time acting on the tissue. Samuel starts essentially from results produced chemically, and explains inflammation as the result of a combination of the chemical irritant with the tissue, the coats of the vessel, and the blood. The migration of blood-cells, their infiltration into the tissue, and the histological processes which result therefrom, are, according to Samuel's view, quite secondary events. If the action of concentrated sulphuric acid on a tissue lead to such metamorphosis that the circulation of the blood and lymph is no longer possible, the tissue is directly killed; the altered condition, however, in which a tissue is found after the absorption of very dilute sulphuric acid (whether at the edge of an eschar produced by concentrated acid, or because only very dilute acid was originally applied), in other words, this interference with the chemistry of the tissue by the action of the acid, by which the blood and lymph circulation, however, is not absolutely destroyed, is the essential cause of inflammation. According to this view, if I have rightly understood Samuel's views, the altered chemical action in the inflamed tissues would vary in each special case; there would be one for acids, another for alkalies, another for ætherial oils (*e. g.* turpentine), another for irritant oils (croton oil) and so on. The condition of the inflamed tissues would vary again when produced by low degrees of cold or by high degrees of heat; it would be different if produced by contusion, or by the action of steam on the free surface of serous membranes, &c. Thus we should have to renounce altogether the idea of acquiring any definite idea of the chemical changes going on in inflamed tissues.

I do not know whether this view would find much acceptance. We have hitherto always included the altered tissue-conditions in our idea of the inflammatory process as a whole, much in the same way as we include under the term concussion of the brain not only the

act of concussion, but also the immediate consequences of this act on the brain and on its function; if an inflammation follow on a concussion of the brain, the condition of the brain, altered by the concussion, may modify the nature and extent of the subsequent inflammation; nevertheless, we are not in the habit of speaking of a concussed brain as an inflamed one. The same applies to contusions; if the normal condition of a tissue be interfered with by a contusion, without, however, having its functions entirely suspended, the changes going on in its blood and lymph channels will hereby be modified, and this modified kind of tissue-life we call inflammation, but not the immediate result of the contusion. Processes for the most part identical—different only in extent and in intensity—which rapidly take place in the tissues as the result of chemical, physical, or mechanical agents, constitute what we commonly call inflammation; the tissue itself, no doubt, plays an important part which may in some measure be modified, but not materially altered, by the action which the inflammatory agent directly exercises on the tissue.

As a visible and constant result of the acute inflammatory process we now see dilatation of the veins and capillaries, with migration of white blood-cells, and with certain disturbances in the physiological functions of the implicated tissues. In order that all this take place, one function certainly of the vessels—that of keeping the cellular elements, the blood within the channels formed for them—must certainly be interfered with; but is such a *functio læsa* really confined to the vessels, or does it extend also to the tissues? It is exceedingly probable. The granular cloudiness which is seen in inflamed muscle, the indistinctness of the fibres in inflamed connective tissue, the granular decay of inflamed nerve-fibres, the rapid decolorisation of the red blood-cells in acutely inflamed tissues, all indicate that certain and constant changes take place in the tissues, which, except in cases where the too rapid and too severe development of these changes leads to gangrene, tend to a gradual decomposition of the tissues or even to their death. I admit that there is at present no proof that these tissue changes commence *simultaneously* with the vascular dilatation, and that they may be regarded as a rapid and an immediate result of this dilatation; for if this tissue change be alone found without vascular dilatation and cell-infiltration, or if these conditions be produced artificially by impeding the flow of blood to the injured part (Samuel), then it

may be argued that such a condition of the tissues ought not to be described as inflammation in the usual sense of the term (Cohnheim).

On the other hand, an attempt has been made to separate the altered condition of the vessels, which allows such free migration of the white cells (suppuration), from inflammation. When we come to consider chronic inflammation we shall see that all these circumstances may really take place separately, and that what we now call acute inflammation only results from a combination of them all.

Virchow some time back decided this question by locating the process of inflammatory nutritive disturbance in great part in the tissues; it was caused partly by the tissue changes already described and visible with the microscope, partly by the observation that in non-vascular tissues, as in the cornea or in cartilage, young cells spring up in the irritated tissue, just as is the case in inflamed vascular tissues. These last observations, which were made at a time when the migration of the white blood-cells was not known, are now open to another explanation. We no more doubt now than formerly that a cartilage cell and many other kinds of cells, as the endothelial cells of serous membranes (Rindfleisch, Kundrat), young epithelial cells (Remak, Buhl, Rindfleisch), form within themselves after certain kinds of irritation, new protoplasm and new cells, then subdivide and so by means of this germination help to the formation of new tissue. It is yet doubtful whether all these so-formed cells possess independent movement like pus-cells; indeed, very few observers now believe that the fixed connective tissue, epithelial and bone corpuscles, acquire this power. It is now generally accepted that suppuration does not result from proliferation of the fixed connective-tissue corpuscles as formerly propounded by Virchow. How far the wandering cells are concerned in inflammatory new growth is by many still regarded as unsettled; according to my own observations I can scarcely doubt that the tissue which brings about primary union, as also granulation tissue, may be formed from the wandering cells, though possibly another mode, budding-out, direct outgrowth of the tissues, is possible. This development of the wandering blood-cells into connective tissue seems to me quite plausible, because the cells, according to my observations, most probably are derived from connective-tissue cells, that is, from the stellate cells and reticular fibres of lymph gland sinuses. The reason why the forementioned tissue cells, for instance, cartilage cells, begin to grow after a little

irritation, then to subdivide and eventually develop into new tissue, is, in recent times, believed to be found in the hypothesis that any protoplasm, which obtains suitable nutritive fluid will grow unhindered and subdivide, unless the pressure of the tissue into which the protoplasm is being developed interferes with and prevents it; the partial setting free of the nucleus, *e. g.* by injury, or a too great yielding of the tissue, may alone suffice, under favorable conditions of nutrition, to set up growth in the portion of the cell still remaining. I consider this hypothesis, first thrown out by Thiersch in connection with another subject to which we shall presently refer, and since warmly taken up by Samuel, exceedingly probable, and believe that it may serve as a basis for further and fruitful research; nevertheless we must not consider that the above question is decided, as the conditions of tissue development depend on many other important factors besides nutrition and pressure; thus, for instance, on the hereditary predisposition of the protoplasm. Neither does the hypothesis fit in cases of endogenous cell development of endothelia after inflammatory irritation of the omentum.

Whether a condition of primary alteration in nutrition takes place in the tissue itself (quite independently of its blood-vessels and their function), which in its turn sets up a specific inflammatory alteration in the vessels, is not known. But it is considered that the accumulation of salts of urea in the tissues of certain parts of the body in arthritis represents this condition, though of course these local accumulations do not exclude vascular participation, nor a simultaneous change both in the vessels and in the soft tissues. It has, further, been demonstrated by one of Cohnheim's experiments that a long-continued shutting-out of the blood from the vessels so acts on the vessel walls, that on readmitting the blood into the vessel, a free migration of blood-cells takes place. It has already been shown that continued stasis does not produce this effect on the walls of those vessels in which the blood stagnates; but from clinical observation it would appear probable that the pressure which vessels, largely and suddenly dilated, exercise on the neighbouring tissue produces slight degrees of inflammation in those tissues.

It would seem very probable that inflammation may be set up not only by the chemical, physical, and mechanical influences which act directly on certain parts, but also that disturbances of nutrition in the tissues themselves and in the circulation, such as take place

within the body without any appreciable external influences, may become causes of inflammation.

There is a symptom which I must not forget to mention, one which formerly played a very important *rôle* in inflammation, and which in modern works on this subject is never mentioned—I refer to the formation of fibrin in certain kinds of inflammation. It is especially, if not altogether, found in inflammations of the connective tissues; sometimes also it is found on the surface of serous cavities, of recent granulating wounds, or on mucous membranes (especially of the nares, larynx, air-passages and bronchial tubes); in other cases there is a fibrinous coagulation of the nutritive juices contained in the connective tissue. It has already been said that this formation of fibrin is not due to any excess of fibrin in the blood, but that it depends on chemical alterations in the inflamed part. Fibrin is formed in inflamed parts: it is a result, though not a constant one, of changes in tissues undergoing inflammation. From a clinical point of view the remarkable difference in the symptoms associated with fibrinous inflammation is very striking. Thus while rapid formation of fibrin to a moderate extent greatly favours and promotes speedy union by the first intention, as also the partial adherence of the surfaces of serous membranes and that too with scarcely a trace of inflammatory or febrile symptoms; in other cases a not very extensive fibrinous coagulation of the tissue, with a slight fibrinous deposit on the mucous membrane of the fauces (diphtheritis), from often inexplicable causes leads to death. It is quite obvious that fibrinous coagulation of the fluids of a tissue is a very grave alteration of nutrition; it often enough, as we know from experience, leads to necrosis of the coagulated tissue.

The severe constitutional symptoms, the intense and extensive inflammatory redness which accompanies the process, cannot well be caused by the formation of fibrin as such: they must be due to the absorption of the products of decomposition from the tissues so affected, and which are so especially liable to produce this poisonous effect.

It appears to me that a similar scale of malignancy is seen in acute inflammations with production of fibrin as in acute inflammatory processes without formation of fibrin: thus this fibrinous exudation would appear as an accident of locality and of tissue, the clinical importance of which is very great, but which does not add

anything of importance to the inflammatory process as such, nor materially change it. Serous effusion also, which mostly accompanies acute inflammations, is also a matter on which we must say a few words. In many cases, no doubt, it is the consequence of altered conditions of pressure in the blood-vessels of the inflamed part: in many cases it is clearly due to the *functio læsa* of the vascular walls and of the tissue around. It is seen in inflammation of connective tissues, especially also of serous membranes, where it becomes a chief symptom. The walls of the blood-vessels are unable to hold the serum of the blood: the tissues do not elaborate it, the veins and lymph-channels only partially carry it away, especially if they are coated with and plugged by lymph as in inflammation of the serous surfaces, on which lymph vessels openly terminate. The serum of acute inflammation differs materially from the serum, which produces dropsy without inflammation; because with the former there are mixed not only wandering cells and broken-down (decolorised) red blood-corpuscles, but also all the soluble products of the inflamed tissue. Even the gradual carrying-away of this fluid by the veins and lymph-vessels, no doubt, on the one hand frees the tissues from a not inconsiderable pressure and thus rids them of dangerous inflammatory products, but on the other hand this drainage, in part at least, takes place into the blood and thereby causes, according to my views, inflammatory fever. I need not now say more on this point, as I have already thoroughly discussed it elsewhere.

Finally, something might be said concerning causes by which circumscribed and often purely mechanical irritants occasionally produce very intense and progressive inflammation, and of the manner in which these inflammations extend. But I will not at present further trouble you. I have already alluded to it, and I will again refer to the subject during my lectures.

Pathological anatomists have not yet devoted much attention to these questions: but surgeons are brought into contact with them only too often, and seek in vain for means by which these progressive inflammations may be momentarily checked. I shall frequently have opportunities in the wards of drawing your attention to this important point.

It is the fashion of the present time for these so-called theoretical reflections, with which I have perhaps wearied very many of you, to be considerably undervalued as to their importance and influ-

ence on practice, and this fashion draws many of you along with it, and induces some not to trouble about the acquirement of this knowledge or to reflect upon it. But I can assure you that in years to come you will scarcely be able to read and understand any medical work, if during your studentship you have not acquired a thorough basis on which further and further to build. I am persuaded that after some years of private practice many of you, who to-day are thoroughly sick of lectures, will yearn after them, and feel anxious to listen once again to a good scientific discourse on some important morbid process. I shall be highly gratified if, in times to come, and in some such spirit as this, you look back on to-day's lecture.

LECTURE XXIII.

CHAPTER XII.

OF GANGRENE.

Dry and moist gangrene.—Immediate causes.—The process of separation.—The different varieties of gangrene according to the remoter causes.—1. Destruction of the vitality of tissue from mechanical or chemical causes.—2. Complete arrest of the afflux and reflux of the blood.—Incarceration.—Continued pressure.—Decubitus.—Over-tension of the tissues.—3. Complete arrest of the supply of arterial blood.—Spontaneous gangrene.—Ergotism.—4. Normal gangrene in various diseases of the blood.—Treatment.

We have already often spoken of gangrene, and of "becoming gangrenous," so that you know what is broadly meant by the term; you have seen a series of cases in which death of tissue occurred locally. There is still a large number of other causes with which at present you are unacquainted, which lead to gangrene; let us group and consider them in the coming chapter.

You are already aware that the word mortification is perfectly synonymous with gangrene; the latter word was originally only applied to the stage in which the dying parts were painful and hot, that is not yet quite dead: this stage was called "hot gangrene"; in some measure it represented the highest grade of acute inflammation. Besides this, the word "sphacelus" was used by the older authorities for moist "cold gangrene." The process of dry gangrene is also called "mummification." Moist gangrene from the very moment when the circulation ceases becomes a process which is entirely analogous with the process of ordinary putrefaction.

Although it is impossible to state definitely why moist gangrene comes on in one case and dry gangrene in another, it may be stated roughly that those parts in which the circulation ceases quickly, especially if they were previously inflamed and œdematous, are attacked by moist gangrene. Dry gangrene, the mummy-like drying up and shrinking of parts, is more frequently the result of a gradual death, during which the circulation in the deeper parts, though becoming weaker and weaker, still goes on for a while; the serum of the gradually necrosing tissues is taken up and carried away by the lymph-vessels and veins. The rapid evaporation of the fluids from without also helps to bring about a gradual drying up of the necrosed parts.

It is equally true that a superficial dryness of the skin may occur in moist gangrene; it is further favoured by removing the easily detached epithelial layer from the decomposing tissues. The drying up may also be greatly promoted by applying to the affected parts any fluids which have any attraction for water, such as alcohol, corrosive sublimate solution, sulphuric acid, and the like: but such a complete mummification as every now and then occurs spontaneously is not very easily attained artificially. Dry gangrene is not a simple decomposition, but rather a complicated process dependent on cessation of the circulation.

The immediate cause of the death of individual parts of the body is always the complete arrest of the supply of nutritious fluids, generally in consequence of suspended circulation in the capillaries: under some circumstances the main arteries and veins of an extremity may become plugged in places, and then the blood finds its way through branches into the upper or lower parts of such vessels. Thus the obstruction of a main artery can only be the immediate cause of gangrene, when collateral circulation is impossible. This may be occasioned partly by special anatomical conditions, partly by great induration of the walls of the smaller arteries, partly by a very extensive injury to the chief arterial stem, as for instance when the femoral artery is plugged from the bend of the thigh right down to the foot; only then, when the capillary circulation is completely arrested by these conditions, will the nutrition cease. But it is not always necessary that cessation of the circulation in a limited capillary district, or in the parts supplied by a small artery, should be followed by actual decomposition; the disturbance in the nutrition may assume another form under these circumstances,

especially if this localised and limited disturbance in the circulation come on gradually and slowly. In this case there is molecular disintegration of the tissue, which shrinks and dries to a yellow cheesy mass; in short, there is a whole series of the metamorphoses which on the dead body we speak of as "dry, yellow infarcts"; these are nothing else than portions of tissue, which, as the result of a kind of dry gangrene confined to a very narrow area, have died. If this disturbance of nutrition and molecular disintegration of tissue occur on an exposed surface, we speak of it as gangrenous ulceration or as dry ulceration; the whole series of so-called atonic ulcers, to which we shall have again to refer, has its cause for the most part in such-like limited disturbances of nutrition. Hence, near as is the connection between dry gangrene and some forms of ulceration as regards cause, still the picture of gangrene in its various forms is thoroughly distinct and peculiar, as the description will show, since there is not only molecular death of the tissues, but also destruction of large tracts and even of entire limbs. It would, *à priori*, be supposed that the complete plugging of all veins returning blood from a limb would lead to complete stasis in the capillaries; but such a condition seldom obtains in actual practice, because the veins are so very numerous, and because there is almost all over the body a double channel for the return of the blood, namely, through the deep and through the subcutaneous veins. Both these systems freely intercommunicate, and when one channel becomes closed, the other will probably be, at least partially, open. When dry gangrene sets in in the skin, and in the more deeply seated soft parts, they usually acquire a greyish-black, and then a coal-black colour. In those cases, in which the parts were previously inflamed the skin generally appears of a dark violet, then of a greenish-yellow colour, and only in case of partial drying up does it become brown or greenish black; necrosed tendons and fasciæ change their colour but very little. When, from disturbance of the circulation, it is clear that a large area of tissue ceases to be nourished, the border line between dead and living becomes more and more marked; a bright red line appears all round the dead skin, the so-called "line of demarcation." This redness is produced by the dilatation of the capillary vessels, which is due partly to collateral circulation and partly to inflammatory hyperæmia from absorption of putrescent fluids. Along with these vascular changes, a rapid infiltration of cells takes place in the line of demarcation on the skin, through

which the tissue itself, whatever its nature may be, is partially softened and loosened. Wandering cells in the form of pus appear along the borders of the living tissue in place of the said tissues, and so the coherence of the parts ceases. The dead detaches itself from the living, and at the edges of the latter there is found tissue changed by plastic infiltration and dilation of vessels, granulation tissue, in fact. Expressed in simple surgical language, we should say, the dead must be separated from the living by vigorous suppuration, and this detachment of necrosed tissue is followed by an active formation of granulations which cicatrise in the usual manner. This process repeats itself after demarcation of the gangrene in all tissues, and in all forms of gangrene, sometimes quicker, sometimes more slowly, but in an exactly identical manner, even in bones, as you already know from the necrosis of fragments in compound fractures. We will not here go into the subject of necrosis of bone, because it is so intimately bound up with other chronic bone diseases, that it will be preferable to speak of it along with them. The time necessary to bring about separation of the necrosed tissue may vary very much. It depends (1) on the size of the piece; (2), on the vascularity and consistence of the tissue; (3), on the strength and vitality of the patient.

As gangrene is the result of other diseases, it is not always easy to group those symptoms which are to be considered as the result of gangrene on the general condition. When the line of demarcation has once formed, and the process of separation is going on, then any effect on the general health-condition only becomes apparent when the gangrene affects considerable portions of extremities. In such cases a marasmic condition sets in, a gradual suspension of all functions, the temperature of the body goes down below normal, the pulse is very small, the tongue dry, a condition of semi-stupor comes on, during which the patients become weaker and weaker, and finally die. In the dead body we are unable in some cases to discover any special destruction of separate organs, while in others we sometimes find metastatic abscesses in the lungs. This is one form of subacute or chronic septicæmia: I have no sort of doubt that the repeated absorption of the putrid fluids formed during the development of the gangrene while the blood and lymph circulation is still going on, may become causes of death. I purpose referring to this subject in the next section.

After these general remarks we must pass on to a more careful

study of the separate forms of gangrene according to their remote or proximate causes, and their practical importance.

1. Complete loss of vitality of the tissues from mechanical or chemical effects, such as crushing, contusions, injuries from heat or cold, or corrosive acids or alkalies. Long-continued contact with ammoniacal urine, with malignant pustular fluid, with putrefying materials, which act as ferments, &c., come into this group. We have already spoken of all these varieties of gangrene, or shall have to do so.

2. Complete arrest of the circulation of the blood, both to and from the part, by means of a circular compression or any other mechanical obstruction is in many cases the cause of capillary stasis and of gangrene. For example, if you tied a string tightly round an extremity, you will first get venous stasis, then œdema, and last of all gangrene. Let us take a practical example: if the prepuce be too narrow, and be drawn forcibly back over the glans so that a paraphimosis result (from φιμος, a muzzle), the constricted glans, or in this especial instance, the constricting ring, may become gangrenous. The gangrenescence of strangulated herniæ depends on the same cause. Continued pressure may likewise cause gangrene by arresting the flow of blood to and from the part, especially in individuals whose heart-power is weakened by long disease, or who are predisposed to gangrene on account of general septicæmia.

Decubitus, the so-called bedsore of sick people, is gangrene of this variety, brought on by continued pressure; but we must just remark that all kinds of bedsores are not necessarily gangrenous; for in many cases it essentially consists in a gradual maceration of the epidermis and derma, which results from long-continued lying in a bed wetted through with sweat, urine, or other fluids. Decubitus very frequently occurs over the os sacrum, and may sometimes attain a very large extent, all the soft parts in the neighbourhood becoming gangrenous down to the bone. It may also occur on the heel, on the trochanter, over the head of the fibula, over the scapula, or the spinous processes of the vertebra, according to the position of the patient. The same thing may be produced by badly fitting instruments. Decubitus is the more serious, because it generally comes on during other exhausting diseases. Although no disease, in consequence of which the patient is condemned to long and absolute rest, is entirely exempt from the fatal complement of decubitus, nevertheless there are diseases

which especially predispose to it, and of these typhoid fever comes first; in septicæmia also decubitus occurs very early, even after three to five days in bed; it is generally preceded by a localised patch of stasis in the skin over the sacrum. On the other hand, phthisical patients, under proper care, may keep their beds for months or years without getting decubitus. Bedsores are very troublesome for patients, especially in chronic diseases, because they are at times accompanied by very great pain. In acute cases of typhoid and septicæmia, on the contrary, the patients sometimes do not feel them, even when the bedsores are very extensive. This variety of bedsore is exceedingly dangerous if the active cause cannot be completely removed, as it tends to become progressive. The prognosis is the more serious in proportion to the exhaustion of the patient; it is even a cause of death in some cases, as it continues to spread more and more in spite of all treatment, and it may become the starting-point of severe pyæmia.

Too great a tension of the tissues, in consequence of which the vessels become distended, and in some places even compressed, leads on the one hand to a decreased blood-supply, while the demand for nutriment is increased; on the other hand, to a coagulation in the capillaries in consequence of increased friction.

Many forms of gangrene probably depend on this cause; such for instance, as occur in inflammation, and which we have already mentioned in speaking of phlegmonous inflammation. It is not, however, to be supposed from this that every blood stasis in the capillaries which may chance to occur in inflammation is to be referred to over-tension in the tissues; there are other causes to be considered also. It would lead me too far were I again to discuss the relation of the blood to the vessel wall; this we have already thoroughly gone into in the chapter on inflammation, and we shall have to further allude to it when treating of venous thrombosis and phlebitis.

The complete arrest of the arterial blood supply, which is chiefly due to heart and arterial disease, must under certain circumstances naturally lead to gangrene; to this class belong those forms of gangrene which are specially called gangrena spontanea, or still more frequently gangrena senilis, because of its occurrence chiefly in old people. This spontaneous gangrene may occur in various ways, and appear under various forms. The causes may be very different, thus thrombosis may begin in the capillaries (marasmatic thrombosis

in consequence of heart debility or insufficient power in the small arteries) or an autochthonous (local) thrombosis occurs, which spreads into the chief arterial trunk, or the thrombosis may result from embola. Further, an advanced degree of anæmia with great secondary narrowing of the vessels and debility of the heart; finally a long-continued spasmodic contraction of arteries may lead to gangrene. True senile gangrene is a disease which originally occurs in the toes; it is very rare in the fingers. I have seen this in one case, however. There are two chief forms: in one form a brown spot occurs on one toe, this changes to a black colour; the spot gradually enlarges and spreads until the whole toe is completely dried up. In favorable cases the demarcation takes place at the metatarso-phalangeal joint, the toe falls off, and cicatrisation takes place. This mummification, however, may spread higher upwards and extend as far as the middle of the foot, or up to the malleoli, or to the middle of the calf, or even close to the knee. In another set of cases the disease begins with symptoms of inflammation, œdematous swelling of the toes, very intense pain in the parts which first turn to a dull blueish red, then to a blackish colour; there are stages in this process during which we may distinctly see by the blueish-red mottling of the skin how the circulation in some places is being carried on under great difficulties, while in other places it has ceased altogether. The French compare this ring of diseased tissue between the dead and the living parts not inaptly to death by suffocation and speak of it as local asphyxia ("asphixie locale"). In this form of moist hot gangrene the disease generally affects several toes at once, then spreads to the foot, so that in the course of some weeks the whole foot, and even the entire leg, becomes gangrenous; in such cases the decomposition early spreads to the œdematous subcutaneous tissue, and thus the danger of purulent infection by the lymphatics is much greater than in the process of mummification. The seat of the vascular disease, which leads to spontaneous gangrene, is very various; in the true (marasmic) gangrena senilis the primary plugging is due to very weak circulation in the capillaries, and this extends backwards into the arteries. This feebleness of the arterial circulation may depend on many causes:—(1) It may be due to lessened activity of the heart; (2) or to thickening of the arterial walls, combined with narrowing of the lumen; (3) to degeneration of the muscular coat of the small arteries. In many cases all these circumstances combine together,

for old persons with feeble hearts are especially liable to disease of arteries; in fact, heart and arterial disease are generally due to one common cause. This is not the place to discuss at any length how far the rigidity and the atheromatous process in the walls of arteries is due to chronic inflammation, or whether it is to be regarded as a special disease, neither can I enter upon the consideration of the finer histological conditions, of which we shall have something to say when treating of aneurisms; I will only say this much, that in old people the arterial walls are often very much thickened, that within them calcareous formations often take place to such an extent that the artery becomes completely calcified, its lumen considerably narrowed, and its interior surface covered with rough projections, which dispose to the formation and entanglement of blood clots. The natural qualities of the arterial walls are lost to such an extent that at last the vessel is neither elastic nor contractile, and thus partly from narrowing, partly from deficient contraction of the vessel, considerable difficulties are placed in the way of the circulation, which is already slow from the want of heart power. It is very easy to imagine how in such cases the circulation may entirely cease, especially in parts which are far distant from the heart.

While the cases just described are very properly termed senile gangrene, and their connection with disease of arteries since Dupuytren's time is generally acknowledged, there is another form of spontaneous gangrene, which certainly may come on in old people, but which is nevertheless materially different from the foregoing; for a large portion of an extremity, for instance, an entire leg as far as the calf or the knee, will all at once become gangrenous.

The process takes place in this manner:—In the main artery, say the femoral, either in the thigh or the ham, a solid clot forms, and becomes adherent to the inner wall of the vessel at spots roughened by previous atheromatous disease, or it forms in sac-like dilatations of the artery, and gradually through the apposition of fresh fibrin, increases in size, until not only the arterial lumen, but also the peripheral portion of the artery as well as a portion of the central extremity are completely plugged up. The consequence of this plugging of the artery, through autocthonous formation of thrombus, which little by little interferes also with collateral circulation, is usually gangrene of the entire foot and of part of the leg; this is dry or moist according to the rapidity with which the clot

has formed: occasionally it is quite possible to observe the growth of the thrombus, by the gradual spread of the gangrene. I once had under observation in Zürich an old man who was admitted into the hospital with spontaneous gangrene of the foot. On account of his emaciated condition, and the great rigidity of the arteries, the pulsation of the femoral could be distinctly traced as low down as the ham. Subsequently the gangrene spread, and the pulsation in the lower part of the artery at the same time ceased; fourteen days later, and a short time only before death, when the gangrene spread to the knee-joint, the pulsation in the femoral had ceased at Poupart's ligament. The autopsy confirmed the diagnosis of complete arterial thrombosis. The gangrenous leg was so completely mummified that it was removed from the body; it was covered over with a coat of varnish, and without further preparation was thus preserved: it is now in the museum at Zürich.

Another cause of arterial thrombosis is where the primary plugging of the artery is due to embolus. A fibrinous clot, which may be detached in endocarditis, or set free from an aneurismal sac, may get wedged in the artery of an extremity; this leads to the further deposit of fibrin. In recent times there is a tendency to ascribe most cases of softening and of induration in the brain or spleen for instance, to such emboli. We recently had a very interesting and typical case of this kind in the wards. A young woman, about six weeks after confinement, had great swelling of the left leg, which was quickly followed by a dark blue discoloration of the skin, and then rapid putrefaction of the limb: there was marked septicæmia when the patient was admitted. As there was no great anæmia, and no disease of arteries could anywhere be discovered in the body, I came to the diagnosis of endocarditis with fibrinous vegetations on the mitral valve, detachment of one of these vegetations and plugging of the left femoral artery at its bifurcation in the popliteal space; and I stuck to this diagnosis although no abnormal heart murmur could be heard, and because it is well known that many an endocarditis may run its course without producing any appreciable symptoms; the sudden putrefaction of the leg must have had some sudden cause. As no line of demarcation formed, and as the general condition of the patient daily became worse, no hope of saving life by amputation could be entertained. The patient died on the twelfth day after the gangrene set in, and the autopsy con-

firmed the diagnosis completely. It seems remarkable that no collateral circulation shonld take place in such cases, as after ligature of the femoral artery. I can only explain this by supposing that the heart's action in endocarditis, which is often complicated with myocarditis, is so materially weakened that the blood pressure is insufficient to dilate the small collateral arteries.

The cases are very rare in which in consequence of excessive anæmia the arteries are so much contracted on the one hand that but little blood circulates through the smaller ones; on the other hand the nervous excitation of the heart is so weak that its contractions are very incomplete. Spontaneous gangrene from this cause is less common in men than in weakly chlorotic women with amenorrhœa: these individuals, who are for the most part young, often suffer from cold moist hands and feet, and from fainting fits, and considerable lassitude; the disease is more common in France than in Germany and England; there is an excellent work on this subject by Rainaud entitled, 'De l'Asphyxie Locale et de la Gangrène symetrique des Extremités,' 1862. As the title expresses it, the gangrene for the most part comes on symmetrically in the two extremities. I have as yet seen only one case which could be classed in this category: a young, exceedingly anæmic man, without any known cause, got gangrene of the tip of the nose, then gangrene of both feet. Death took place after some months of suffering: as during life, so in the dead body, beyond an extreme and inexplicable poverty of blood, I could not find any disease.

The form of gangrene which is observed as the result of eating ergot is considered to be due to a continuous spasmodic contraction of the smaller arteries. This substance causes an increased contraction of the organic muscular fibres, especially of those of the uterus and of the uterine arteries.

Ergot (blighted corn, secale cornutum) is a diseased grain, growing out from the ears of rye (secale cereale), in which a peculiar material called ergotin is formed. If bread be made from such grain, the persons eating it are affected with very peculiar symptoms, which are classed under the term ergotism. As this diseased condition of the grain is confined to certain districts, so, naturally, the disease breaks out epidemically in men and animals. The disease has been known for a very long time: it was first accurately described during an epidemic in France during the year 1630. In Germany the disease appears to be very rare, as also in England, and in

Italy. In recent times it has scarcely ever occurred; this may be easily explained by the fact that the diseased grain is now better known and is not used for bread, and also because comparatively less corn is now grown since potatoes have been more extensively cultivated.

From the existing descriptions of this disease we may gather that various forms and types have presented themselves, and that first one and then another has prevailed during different epidemics: perhaps the poison is not always the same, or at least differs in its intensity. In the very acute cases the patients are attacked very early with violent and general cramp, and death takes place in from four to eight days; other cases have a longer course: the cramp only comes on from time to time. During the premonitory stages there is great itching and creeping of the skin, particularly of the hands: to this succeeds a feeling of numbness, anæsthesia in the tips of the fingers, combined with dry, seldom with moist gangrene of the skin, then of the whole extremity. In the more chronic cases the result is more favorable, though several fingers or toes may be lost.

It only remains to speak of some forms of gangrene, the causes of which are not accurately known, and in which probably several causes combine. Among these is the so-called water-canker or noma, a spontaneous form of gangrene, occurring in children and most frequently on the cheek: it is especially common in towns on the Baltic, and very much less so inland. Very debilitated children who live in cold moist habitations are especially liable to this disease: it manifests itself as a gangrenous spot in the middle of the cheek or lip, coming without any known cause; it spreads most rapidly, until the children at last die of exhaustion.

Whether in these cases anæmia with feebleness of the heart is the only cause, or whether miasmstic influences help, or whether there is any special disease of the blood, is very doubtful. That certain diseased conditions of the blood predispose to gangrene we have already mentioned in our remarks on decubitus in septicæmia. We must also include here the occurrence of gangrene after typhoid, intermittent, and exanthematic fevers, also in diabetes mellitus, Bright's disease, &c. After, and also during these diseases, gangrene of the tip of the nose, of the ear, of the lips, of the cheek, or of the hands and feet sometimes occurs. In rare cases an exanthem may pass into superficial gangrene. In such cases we must consider that the miasma which

induced the typhoid exercised some influence also on the production of the gangrene: on the other hand, there is some ground for the belief that the gangrene is, for the most part, the result of the great debility of the heart's action consequent on a long illness; in consequence of this there is not power to force the blood into the distant parts of the body with sufficient force; the gangrene is thus the result of a miasmatic capillary thrombosis. Estlander has very recently made some interesting observations on gangrene of the lower extremities in typhus fever, and has arrived at the conclusion that this form of gangrene is partly caused by emboli, which most probably result from miasmic thrombi in the left heart. No doubt different conditions obtain in individual cases more or less, and thus no uniform ætiology suitable for all cases can be laid down. I will just mention that the stomatitis which results from the over-use of mercury shows a great disposition to gangrene. We shall speak further on of a form of gangrene peculiar to wounds—hospital gangrene.

At the commencement of this chapter I have said that "the immediate cause of the death of individual parts of the body is always the complete arrest of the supply of nutritious fluids, *generally* in consequence of suspended circulation in the capillaries." This admits the possibility that gangrene may also occur even while the circulation continues: formerly I did not consider this to be possible, that is, I could not conceive dead gangrenous tissue with capillary circulation. Observations at the bedside, together with the impressions which Samuel's researches on inflammation have produced on me, have led me to believe, however, that such is possible; that, in fact, the inflammatory disturbance of the nutrition of the tissue, of which we have already spoken, is sometimes so intense and spreads so rapidly, as to lead directly to the arrest of tissue change, even before stasis and coagulation in the vessels can take place. The blood then circulates in the tissues in which, however, the normal functions of tissue changes are no longer performed, but in which the contained juices decompose in an entirely independent manner, identical probably in the immediate products of its decomposition with putrefaction. Cases of panaritium occur and more rarely of phlegmon, which so rapidly become gangrenous, that from analogies with other tissues it is highly improbable that it is not the result of arterial thrombosis: the capillary circulation no doubt soon ceases if the tissue becomes

primarily gangrenous, but then this is not the result of circulatory disturbance in the arteries and veins as in the gangrene of strangulation, but in consequence of the destruction of the function of the vessel walls by the inflammatory process, which I look upon as a higher degree of the inflammatory alteration (Cohnheim), and which in such cases is very rapidly gone through, almost passed over. A similar rapid change from inflammatory alteration to destruction of tissue can also be brought about especially by septic products: probably the poison of snakes acts in this manner, but of this we shall speak later. Then also fibrinous infiltration of the cellular tissue (diphtheritic phlegmon) must once again be mentioned. It would seem from some clinical observations as if fluid blood may still continue to flow for a time through the vessels of tissues, the juices of which are almost completely coagulated, and that the thrombosis in some of these cases is only the result of cellular infiltration, and further that the tissue under these circumstances dies before the circulation is completely stopped.

It is at present impossible to draw any exact conclusions as to the signification of these facts, and I only refer to them in the hope, should any opportunities offer, that you will devote all your attention to these highly important changes. The view is not novel, for the older surgeons regarded gangrene as the most potent of all inflammations.

There are some very important rules for the prevention of gangrene, especially of decubitus and other forms due to pressure: even from gangrene inflammation may be prevented under certain circumstances by relieving the great tension of the tissues and the venous congestion by early and well-timed incisions.

As preventive measures against bedsores, bear the following rules in mind: never forget to pay due attention to this point, especially in diseases which predispose to this complication: The most suitable sick-bed is a horse-hair mattress; the sheets must always be kept smooth, so that the patient never lies on folds. As soon as any redness of the skin appears over the sacrum, you must be doubly careful about the fæces and urine, lest the bed be wetted through. Slice a lemon and let the reddened spot be rubbed daily with the fresh juice from the cut surface. If the excoriation appear over the sacrum, immediately place the patient on a horse-shoe cushion, or if it can be had, on a good air or water cushion. The excoriated place may be painted with nitrate of silver, or may be

covered over with a washleather plaster. If the decubitus is gangrenous from the first, and seems inclined to spread, the ordinary treatment of gangrene must be adopted, of which we shall speak presently.

The local treatment of the commencing gangrene has two chief objects in view :—(1). The separation of the gangrenous portions by the promotion of active suppuration, with which the arrest of the gangrene is intimately connected; (2). The prevention of decomposition (in the gangrenous portions) which acts injuriously on the patient and renders the air of the room pestilential.

For the accomplishment of the first indication moist warmth in the form of poultices was formerly much used. I cannot find, however, that they are particularly useful in these cases. If the gangrene is moist, and if the gangrenous parts are disposed to decompose, the application of cataplasms would only tend to favour it; while for the separation of a dry eschar which does not smell badly, if the line of demarcation be already formed, it is scarcely worth the trouble to hasten the process of separation by a short time by the use of warmth. I prefer therefore very much to cover the gangrenous parts and the edges of the healthy tissue with lint freely soaked in chlorine water, and by the use of the same means in moist gangrene I have succeeded in lessening the disagreeable odour of the decomposing tissues. For the same purpose we may use creasote water, or carbolic acid lotion, or dilute purified pyroligneous acid, very strong alcohol, spirits of camphor, or oil of turpentine. Charcoal powder dusted thickly over a part absorbs the gases, which develope in the putrefying tissue, but it is only little used, because it soils wounds, bandage, and everything else with which it comes in contact. Besides these there are other powerful antiseptics, the acetate of alumina, and coal-tar with plaster of Paris: both remedies are very simple, but they, like all others of this class, must be frequently renewed day and night, if they are to be efficacious in removing the offensive smell. Latterly the permanganate of potash (1—100) has become greatly prized not only as a local antiseptic, but also as a disinfectant. I have made rather extensive trials with this fluid, but find it very inferior to those previously mentioned. Concentrated solutions of carbolic acid in olive oil (1—50) cause symptoms of poisoning (olive-coloured urine), and hence they must be used with caution. So soon as the gangrenous mass has become somewhat loosened, the threads must be cut through with scissors,

without, however, cutting into the sound tissue; for this is of great importance, especially in extensive gangrene of subcutaneous cellular tissue, as, for instance, after extravasation of urine; then the local antiseptic treatment must be continued until healthy granulation is well established. Guided by the anatomical conditions in spontaneous gangrene, it has been advised in the early stage of gangrene to break up the blood coagula in the limb by friction and by stroking the limb; this method, on account of the pain and the swelling of the part, is only occasionally practicable. In those cases in which I tried this treatment it produced no good effect as far as the spread of the gangrene was concerned.

If the gangrene affect a whole limb, as in the different forms of spontaneous and senile gangrene, I would strongly advise you not to undertake any operation until the line of demarcation is definitely formed. If there is gangrene of single toes, wait until they separate; if the gangrene affect the entire foot or leg, arrange to do the amputation in such a manner that it becomes an aid to the normal process of separation; that is to say, you endeavour to take only just sufficient skin along the healthy margin to cover the amputated surface, and you saw through the bone, at the nearest spot to the line of demarcation. With such precautions you will occasionally succeed in arresting any further outbreak of gangrene, and in preserving the patient's life. If the patient die before a distinct line of demarcation has formed, as is very frequently the case, you need not reproach yourselves for having deferred the amputation, for it is almost certain that the patient, if you had performed amputation, would have probably died even more quickly. The *prognosis* in gangrene from internal causes (as the older surgeons expressed it) is generally unfavorable.

As regards the general internal treatment of gangrene, it must be strengthening, and in some cases even stimulating. A generous diet, with quinine, acids, and occasionally a few doses of camphor, are indicated. The severe pain in senile gangrene render opium necessary, often even in large doses, or subcutaneous injection of morphia renders good service. For gangrene in mercurial stomatitis there is no definite antidote, but the use of mercury must at once be suspended; if mercurial ointment has been applied, the patient must be put into a warm bath and washed; he should be placed in a fresh, well-ventilated room, with clean body and bed linen, and have ordered a gargle either of chlorate of potash or chlorine water.

Neither have we any antidote for the ergotine, which causes ergotism; emetics, quinine and its preparations, and carbonate of ammonia, are mostly recommended. We can only cut off the continued absorption of putrescent materials into the blood by amputation of the diseased part; and we have already pointed out what an uncertain remedy this is, especially in spontaneous gangrene.

END OF VOL. I.

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